MILITARY MEDICAL MANUALS

GENERAL EDITOR:
SURGEON-GEN. SIR ALFRED KEOGH
G.C.B., M.D., F.R.C.P.

TREATMENT OF FRACTURES

R. LERICHE
EDITED BY
F. F. BURGHARD

31761 06705383 5

MILITARY MEDICAL MANUALS

GENERAL EDITOR :

SIR ALFRED KEOGH, G.C.B., M.D., F.R.C.P.

THE TREATMENT OF FRACTURES

VOL. I

MS
L

THE TREATMENT OF FRACTURES

BY

R. LERICHE

Assistant Professor in the Faculty of Medicine, Lyons

EDITED, WITH A PREFACE, BY

F. F. BURGHARD, C.B., M.S. (Lond.), F.R.C.S.

Surgeon to King's College Hospital, and lately Consulting Surgeon to the British Armies in France

I

FRACTURES INVOLVING JOINTS

WITH 97 ILLUSTRATIONS

147247
5/10/18

UNIVERSITY OF LONDON PRESS, LTD.

18 WARWICK SQUARE, LONDON, E.C.4

PARIS: MASSON ET CIE, 120 BOULEVARD SAINT-GERMAIN

1918

GENERAL INTRODUCTION

THE infinite variety of injuries which any war presents to the surgeon gives to military surgery a special interest and importance. The special interest and importance, in a surgical sense, of the great European War lies not so much in the fact that examples of every form of gross lesion of organs and limbs have been seen, for if we read the older writers we find little in the moderns that is new in this respect, but is to be found in the enormous mass of clinical material which has been presented to us and in the production of evidence sufficient to eliminate sources of error in determining important conclusions. For the first time also in any campaign the labours of the surgeon and the physician have had the aid of the bacteriologist, the pathologist, the physiologist, and indeed of every form of scientific assistance, in the solution of their respective problems. The clinician entered upon the great war armed with all the resources which the advances of fifty years had made available. If the surgical problems of modern war can be said not to differ sensibly from the campaigns of the past, the form in which they have been presented is certainly as different as are the methods of their solution. The achievements in the field of discovery of the chemist, the physicist, and the biologist have given the military surgeon an advantage in diagnosis and treatment which was denied to his predecessors, and we are able to measure the effects of these advantages when we come to appraise the results which have been attained.

But although we may admit the general truth of these statements, it would be wrong to assume that modern scientific knowledge was, on the outbreak of the war, immediately useful to those to whom the wounded were to be confided. Fixed principles existed in all the sciences

auxiliary to the work of the surgeon, but our scientific resources were not immediately available at the outset of the great campaign; scientific work bearing on wound problems had not been arranged in a manner adapted to the requirements—indeed, the requirements were not fully foreseen; the workers in the various fields were isolated, or isolated themselves, pursuing new researches rather than concentrating their powerful forces upon the one great quest.

However brilliant the triumphs of surgery may be—and that they have been of surpassing splendour no one will be found to deny—experiences of the war have already produced a mass of facts sufficient to suggest the complete remodelling of our methods of education and research.

The series of manuals, which it is my pleasant duty to introduce to English readers, consists of translations of the principal volumes of the " Horizon " Collection, which has been appropriately named after the uniform of the French soldier.

The authors, who are all well-known specialists in the subjects which they represent, have given a concise but eminently readable account of the recent acquisitions to the medicine and surgery of war which had hitherto been disseminated in periodical literature.

No higher praise can be given to the Editors than to say that the clearness of exposition characteristic of the French original has not been lost in the rendering into English.

MEDICAL SERIES

The medical volumes which have been translated for this series may be divided into two main groups, the first dealing with certain epidemic diseases, including syphilis, which are most liable to attack soldiers, and the second with various aspects of the neurology of war. The last word on *Typhoid Fever*, hitherto " the greatest scourge of armies in time of war," as it has been truly called, will be found in the monograph by MM. Vincent and Muratet, which contains a full account of recent progress in bacteriology and epidemiology as well as the clinical features of typhoid and paratyphoid fevers. The writers combat a belief in the comparatively harmless nature of para-

typhoid and state that in the present war hæmorrhage and perforation have been as frequent in paratyphoid as in typhoid fever. In their chapter on diagnosis they show that the serum test is of no value in the case of those who have undergone anti-typhoid or anti-paratyphoid vaccination, and that precise information can be gained by blood cultures only. The relative advantages of a restricted and liberal diet are discussed in the chapter on treatment, which also contains a description of serum-therapy and vaccine-therapy and the general management of the patient.

Considerable space is devoted to the important question of the carrier of infection. A special chapter is devoted to the prophylaxis of typhoid fever in the army. The work concludes with a chapter on preventive inoculation, in which its value is conclusively proved by the statistics of all countries in which it has been employed.

MM. Vincent and Muratet have also contributed to the series a work on *Dysentery, Cholera, and Typhus* which will be of special interest to those whose duties take them to the Eastern Mediterranean or Mesopotamia. The carrier problem in relation to dysentery and cholera is fully discussed, and special stress is laid on the epidemiological importance of mild or abortive cases of these two diseases.

In their monograph on *The Abnormal Forms of Tetanus*, MM. Courtois-Suffit and Giroux treat of those varieties of the disease in which the spasm is confined to a limited group of muscles, *e.g.* those of the head, or one or more limbs, or of the abdomino-thoracic muscles. The constitutional symptoms are less severe than in the generalised form of the disease, and the prognosis is more favourable.

The volume by Dr. G. Thibierge on *Syphilis and the Army* is intended as a *vade mecum* for medical officers in the army.

Turning now to the works of neurological interest, we have two volumes dealing with lesions of the peripheral nerves by Mme. Athanassio-Benisty, who has been for several years assistant to Professor Pierre Marie at La Salpêtrière. The first volume contains an account of the anatomy and physiology of the peripheral nerves,

together with the symptomatology of their lesions. The second volume is devoted to the prognosis and treatment of nerve lesions.

The monograph of MM. Babinski and Froment on *Hysteria or Pithiatism and Nervous Disorders of a Reflex Character* next claims attention. In the first part the old conception of hysteria, especially as it was built up by Charcot, is set forth, and is followed by a description of the modern conception of hysteria due to Babinski, who has suggested the substitution of the term "Pithiatism," *i.e.* a state curable by persuasion, for the old name hysteria. The second part deals with nervous disorders of a reflex character, consisting of contractures or paralysis following traumatism, which are frequently found in the neurology of war, and a variety of minor symptoms, such as muscular atrophy, exaggeration of the tendon reflexes, vasomotor, thermal and secretory changes, etc. An important section discusses the future of such men, especially as regards their disposal by medical boards.

An instructive companion volume to the above is to be found in the monograph of MM. Roussy and Lhermitte, which embodies a description of the psychoneuroses met with in war, starting with elementary motor disorders and concluding with the most complex represented by pure psychoses.

SURGICAL SERIES

When the present war began, surgeons, under the influence of the immortal work of Lister, had for more than a quarter of a century concerned themselves almost exclusively with elaborations of technique designed to shorten the time occupied in or to improve the results obtained by the many complex operations that the genius of Lister had rendered possible. The good behaviour of the wound was taken for granted whenever it was made, as it nearly always was, through unbroken skin, and hence the study of the treatment of wounds had become largely restricted to the study of the aseptic variety. Septic wounds were rarely seen, and antiseptic surgery had been almost forgotten. Very few of those who were

called upon to treat the wounded in the early autumn of 1914 were familiar with the treatment of grossly septic compound fractures and wounded joints, and none had any wide experience. To these men the conditions of the wounds came as a sinister and disheartening revelation. They were suddenly confronted with a state of affairs, as far as the physical conditions in the wounds were concerned, for which it was necessary to go back a hundred years or more to find a parallel.

Hence the early period of the war was one of earnest search after the correct principles that should be applied to the removal of the unusual difficulties with which surgeons and physicians were faced. It was necessary to discover where and why the treatment that sufficed for affections among the civil population failed when it was applied to military casualties, and then to originate adequate measures for the relief of the latter. For many reasons this was a slow and laborious process, in spite of the multitude of workers and the wealth of scientific resources at their disposal. The ruthlessness of war must necessarily hamper the work of the medical scientist in almost every direction except in that of providing him with an abundance of material upon which to work. It limits the opportunity for deliberate critical observation and comparison that is so essential to the formation of an accurate estimation of values ; it often compels work to be done under such high pressure and such unfavourable conditions that it becomes of little value for educative purposes. In all the armies, and on all the fronts, the pressure caused by the unprecedented number of casualties has necessitated rapid evacuation from the front along lines of communication, often of enormous length, and this means the transfer of cases through many hands, with its consequent division of responsibility, loss of continuity of treatment, and absence of prolonged observation by any one individual.

In addition to all this, it must be remembered that in this war the early conditions at the front were so uncertain that it was impossible to establish there the completely equipped scientific institutions for the treatment of the wounded that are now available under more assured circumstances, and that progress was thereby

much hampered until definitive treatment could be undertaken at the early stage that is now possible.

But order has been steadily evolved out of chaos, and many things are now being done at the front that would have been deemed impossible not many months ago. As general principles of treatment are established it is found practicable to give effect to them to their full logical extent, and though there are still many obscure points to be elucidated and many methods in use that still call for improvements, it is now safe to say that the position of the art of military medicine and surgery stands upon a sound foundation, and that its future may be regarded with confidence and sanguine expectation.

The views of great authorities who derive their knowledge from extensive first-hand practical experience gained in the field cannot fail to serve as a most valuable asset to the less experienced, and must do much to enable them to derive the utmost value from the experience which will, in time, be theirs. The series covers the whole field of war surgery and medicine, and its predominating note is the exhaustive, practical, and up-to-date manner in which it is handled. It is marked throughout not only by a wealth of detail, but by clearness of view and logical sequence of thought. Its study will convince the reader that, great as have been the advances in all departments in the services during this war, the progress made in the medical branch may fairly challenge comparison with that in any other, and that not the least among the services rendered by our great ally, France, to the common cause is this brilliant contribution to our professional knowledge.

A glance at the list of surgical works in the series will show how completely the ground has been covered. Appropriately enough, the series opens with the volume on *The Treatment of Infected Wounds*, by A. Carrel and G. Dehelly. This is a direct product of the war which, in the opinion of many, bids fair to become epoch-making in the treatment of septic wounds. It is peculiar to the war and derived directly from it, and the work upon which it is based is as fine an example of correlated work on the part of the chemist, the bacteriologist, and the clinician as could well be wished for. This volume will show many

for the first time what a precise and scientific method the "Carrel treatment" really is.

The two volumes by Professor Leriche on *Fractures* contain the practical application of the views of the great Lyons school of surgeons with regard to the treatment of injuries of bones and joints. Supported as they are by an appeal to an abundant clinical experience, they cannot fail to interest English surgeons, and to prove of the greatest value. It is only necessary to say that *Wounds of the Abdomen* are dealt with by Dr. Abadie, *Wounds of the Vessels* by Professor Sencert, *Wounds of the Skull and Brain* by MM. Chatelin and De Martel, and *Localisation and Extraction of Projectiles* by Professor Ombrédanne and R. Ledoux-Lebard, to prove that the subjects have been allotted to very able and experienced exponents.

ALFRED KEOGH.

EDITOR'S PREFACE

THE appearance of Professor Leriche's monograph upon the Treatment of Fractures in War is sure of a welcome from every surgeon who has to treat these serious and difficult cases. From the very beginning of the war it became obvious that in fractures the medical services have to deal with a group of cases that is not only numerically very large, but from an economic point of view most important. The experiences of the first few months showed that, so far from being the benign injuries that experience in the South African campaign had led many observers to suppose them, they were perhaps the most to be feared of all wounds because of their liability to dramatically serious complications in the early days, and to lasting disability later on. Without taking into account the large numbers of deaths that have occurred from hæmorrhage, shock, and sepsis in these cases, the great numbers of the amputated bear eloquent testimony to the permanent drain upon the nation caused by war fractures.

Therefore it soon became clear that no effort should be spared to find any method of treatment that would lessen this drain, and the most serious attention of surgeons was focussed upon this object. It is true that they had the great advantage of abundance of material upon which to work, an advantage often denied to researchers in times of peace, but this was more than counterbalanced by the disadvantageous conditions under which the work had necessarily to be done. The unavoidable hurry during the phenomenal

"rushes" of work, the rapid evacuation, and the impossibility of following up the cases or even learning the end-results of the treatment within a reasonable time, all militated against the careful comparison of results that alone would justify any sound pronouncement as to the merits of any particular form of treatment.

But gradually general principles of treatment were evolved and have now become established. The primary importance of early operative treatment as practically the only means of avoiding those terrible septic complications that are the cause of the great majority of the bad results has become firmly established, and this has led to most of the really important surgery being performed at our casualty clearing-stations near the front, instead of, as formerly, at the base. This in its turn has led to the equipment of the casualty clearing-stations, both as regards material and personnel, with all that is required for the performance of surgery of the best type. Hence instead of the old practice of hurrying the wounded man through the casualty clearing-station in order that he may be sent down to the base for treatment, we now have the infinitely sounder practice of retaining him in the C.C.S. until he has had complete operative treatment and is in a condition to be sent safely to the base, where his cure can be completed.

This revolution in organisation has enabled the surgery of the wounded to be carried out upon lines more consonant with the general principles of the surgery of peace, which after all, as Professor Leriche points out, do not vary. The only question in war is how far they can be applied to the cases under consideration. Increasing experience has shown that the results become better as the surgeon becomes enabled to practise his art in surroundings and under conditions that approximate more nearly to those of peace-time.

In the present volume, which, dealing with fractures of the articular ends of bones, is really a monograph upon injuries of joints, Professor Leriche lays quite rightly the utmost stress upon these points. The only way in which to obtain good results is to operate early, to operate radically, and to impress upon all concerned the fact that the surgeon in charge of the after-treatment has as great a responsibility for the end-result as he who did the operation. Only thus can we hope to get results which surgical science should be expected to obtain, and thus they should certainly be obtained.

The views put forward in this volume are those of the great Lyons school of surgeons, of which Ollier was the high-priest and of which Professor Leriche is a distinguished disciple. It is not within my province, nor is it my desire, to criticise them. They have been widely discussed and are even now not accepted by many, but Professor Leriche states his case most ably and logically, and adduces his evidence in support of his views. The general principles that he enunciates cannot be gainsaid, and every surgeon will, I am sure, read the book with great interest and profit. He will then be acquainted with the practice, in full detail, of one who has put that practice to the test under the severest conditions, and he cannot fail to derive from it information and instruction that will prove of the greatest value.

Above all, I recommend Professor Leriche's Introduction to the most serious consideration of all, medical officers, surgical specialists and administrators, who are concerned in the treatment of war-fractures. It is a true surgical sermon, which, if laid to heart and acted upon by all who read it, cannot fail still further to improve the already greatly improved treatment of these formidable injuries.

F. F. Burghard.

CONTENTS

PAGE

INTRODUCTION xxi

CHAPTER I

GENERAL CONSIDERATIONS UPON WOUNDS OF JOINTS, THEIR GRAVITY AND THEIR TREATMENT . 1

I. Gravity of Wounds of Joints . . 1
II. General Treatment of Wounds of the Synovial Membrane and of Compound Fractures into Joints . . . 8
III. General Technique of Operations upon the Joints 18

CHAPTER II

WOUNDS AND FRACTURES OF THE SHOULDER . 34

I. Anatomical Types and Clinical Course . 34
II. Primary Therapeutic Indications . . 37
III. Operative Technique 44
IV. Post-Operative Treatment . . . 49
V. Evacuation of Patients with Shoulder Wounds 56
VI. Treatment of Patients seen late or after Evacuation 57

CHAPTER III

PAGE

Wounds and Fractures of the Elbow . . 61

I. Anatomical Types and Clinical Course . 61
II. Primary Therapeutic Indications . . 66
III. Operative Technique 81
IV. After-Treatment 86
V. Evacuation of Patients with Elbow Wounds 92
VI. Treatment of Patients seen late or after Evacuation 94

CHAPTER IV

Wounds and Fractures of the Wrist . . 102

I. Anatomical Types and Clinical Course . 102
II. Primary Therapeutic Indications . . 103
III. Operative Technique 107
IV. Post-Operative Treatment . . . 109
V. Evacuation of Patients with Wrist Wounds 112
VI. Treatment of Patients seen late or after Evacuation 112

CHAPTER V

Wounds and Fractures of the Hip . . . 116

I. Anatomical Types and Clinical Course . 116
II. Primary Therapeutic Indications . . 119
III. Operative Technique 122
IV. Post-Operative Treatment . . . 125
V. Evacuation of Patients with Hip Wounds 129
VI. Treatment of Patients seen late or after Evacuation 129

CHAPTER VI

PAGE

WOUNDS AND FRACTURES OF THE KNEE . . 133

I. Anatomical Types and Clinical Course . 133
II. Primary Therapeutic Indications . . 138
III. Operative Technique 148
IV. Post-Operative Treatment . . . 150
V. Evacuation of Patients with Knee Wounds 157
VI. Treatment of Patients seen late or after Evacuation 157

CHAPTER VII

WOUNDS AND FRACTURES OF THE ANKLE . . 166

I. Anatomical Types and Clinical Course . 166
II. Primary Therapeutic Indications . . 170
III. Operative Technique 177
IV. Post-Operative Treatment . . . 180
V. Evacuation of Patients with Ankle Wounds 184
VI. Treatment of Patients seen late or after Evacuation 184

CHAPTER VIII

WOUNDS AND FRACTURES OF THE ANTERIOR TARSUS AND THE FORE-PART OF THE FOOT . . 187

I. Anatomical Types and Clinical Course . 187
II. Primary Therapeutic Indications . . 188
III. Operative Technique 194
IV. Post-Operative Treatment . . . 198
V. Evacuation of Patients with Anterior Tarsal Wounds 200
VI. Treatment of Patients seen late or after Evacuation 200

CHAPTER IX

MULTIPLE JOINT WOUNDS 204

INTRODUCTION

THIS little book contains none but practical and *established* information; neither theoretical discussions, founded upon more or less trustworthy statistics of former wars, nor purposeless bibliographical details will find a place in it. It is the simple statement of a personal experience directly inspired by the traditions of a school specialising in the surgery of the bones and tested in the different surgical departments of the Army Medical Service—sorting ambulances, divisional ambulances, military evacuation hospitals, and the base hospitals fifty miles from the front.

My desire is to make the book a study of surgical therapeutics without reference to symptoms or diagnosis. But surgical treatment does not mean merely operative technique, which is only one part of surgery, and though certainly essential, in my opinion not the most important, especially in these times. The surgeon who is only an operator, who is interested in nothing besides the display of his skill in public, is very far from perfection in times of peace; in war, he becomes a public calamity, for in the treatment of war wounds operative measures are only the initial stage of the treatment. Want of care must jeopardise the final result of even the best executed operation. It is well to insist upon this, for as a result of military exigencies the operator at the present time is generally unable to follow his patient to the end. Every surgeon should therefore devote great care to the results of operations, even of those he has not performed himself; he should

use his best endeavours, realising that more skill is required to procure satisfactory mobility for a newly-made elbow joint than to perform the operation itself.

If the surgeon at the base who takes charge of a case that has been already operated upon is a mere technician, heedless of the real care of the wounded and ignorant of the fundamental rules of the reparative treatment of wounds, the most legitimate operations from a physiological standpoint only meet with failure. It is by culpable negligence of this kind that the soundest indications for any given operation are completely nullified.

It is for these reasons that I have planned this book as a handbook of the treatment of joints in which will be indicated for each joint the mode of carrying out the treatment during the different stages through which the wound passes. By relying upon the general principles and the specific details therein indicated—which are those of the Lyons school of surgery—it is certain that, in operations correctly performed, the orthopædic and functional results obtained will justify the operative indications I have laid down. This optimism should not cause surprise. Surgical treatment has advanced so far in many directions that an operation may be likened to a physiological experiment : once the conditions are determined, the process infallibly progresses to a known result. There is no sphere in which it is possible to be more exact than the treatment of joints : thanks to the works of Ollier, the whole of one category of articular operations is now known ; the good physiological result which a subperiosteal resection effects is certain, if one strictly complies with the conditions necessary for the reconstitution of a mobile joint, and if no unlooked-for complications supervene. But in order that this should be so and that nothing should interfere with the progress of the wound in question, infection and all its accompanying dangers must not be allowed to invali-

date the result. It is absolutely necessary to open up the affected area early enough to ensure prophylaxis against the infections which threaten all war wounds, and also to ensure *the clinically aseptic course of the case* by exposure to the air, after the method of Poncet. This is most important.

Operative procedure ought to be prompt and follow as quickly as possible on the injury, in order to obtain regular and certain results. That is why in this little work I have put myself in the place of the surgeon at the front, to whom I shall endeavour to indicate a method founded upon proved experience.

It is at the front indeed that almost all the military surgery should be done; if it were done there as it ought to be, the base hospitals would be able to serve merely as institutions for the aseptic healing of wounds, centres for dressing, for physical exercises, and for orthopædics in the largest sense of the word. In them the cares of operating would not be liable to interfere with the daily supervision of the patients who have already been operated upon at the front; this would conduce greatly to their advantage.

But if the ambulance surgeon is to perform almost all the surgical operations, it is important that an exact knowledge of the therapeutical outlook, a sound technique, and precise and orthodox surgical methods should be required of him. It is not sufficiently realised that he has no right to hesitate, that he has to decide in a few moments upon the life and future of the wounded often under unheard-of conditions of overwork and fatigue. He cannot regulate the events of even the next hour for himself or his patient; he has to act quickly and to choose at once the safest and best operation without being able to put it off until to-morrow or to take advice. For him all wounds are alike; they are recent and appear aseptic, yet grave danger threatens. It is his duty to intervene, not in consequence of existing clinical indications of sepsis,

but solely because of the probability of its advent, *so that the wounded may be evacuated without danger as quickly as possible.* He knows that among those who are brought to him there are none whose wounds are negligible, and that the patient who, to all appearances, is scarcely touched, will perhaps to-morrow have a very severe arthritis, a spreading cellulitis, or a gaseous gangrene. Experience has taught him that if he sends away men whose wounds have not been cleaned up or have been insufficiently operated upon, some of them after a few hours' journey will have to undergo amputation, and others will die. It is his clear duty to prevent these results by practising a rigorous prophylaxis in all cases without distinction. The choice of operation, then, must be a reflex act determined by a survey of the extent of the lesion, but his surgical sense ought to be such that it is always automatically governed by the desire to preserve the patient's life, his limb and its functions.

But although this conservation should be the main object, he must not put off his decisions until he can do so no longer, nor should he do only the minimum for fear of doing too much, nor, when he is compelled to do something, should he do it with timidity.

If a surgeon has such a false sense of conservatism in surgery there is grave risk of finding that sepsis has already occurred, and of being frequently too late in operating. The surgery which is characterised by doing as little as possible and which conceals behind a mask of clinical wisdom the terror of the responsibilities of operating and the fear of being wanting in technical skill, almost always fails to secure adequate results ; even though it avoids using the knife and counts the cures it has obtained at little cost, it will never dare to compile a balance sheet of the deaths it has caused, of the limbs it has eventually been obliged to sacrifice, or of the functional movements which it has left irremediably damaged. The partisans

of this type of surgery still speak of the treatment of gas gangrene instead of its prophylaxis. In that sentence the whole situation is summed up.

True conservative surgery is quite another thing: it is always active, incising all those wounds which experience has shown to be in constant danger of infection (*that is, all those which are not punctiform bullet wounds*), sterilising them by exposure to air, removing as a first step all foreign bodies from a joint, resecting at once any joint involved, without waiting for the clinical appearances of articular osteomyelitis. It is always practising prophylaxis, and consequently the wounds which it treats pursue their course without the appearance of pus: *it has achieved the feat of becoming aseptic surgery.* It no doubt incises joints which would have got well without incision, but it saves limbs which hesitation would have lost; it does not have to fight against gangrene and septicæmia, more powerful than itself; it does not lose its operative cases from secondary hæmorrhage; it does not amputate for suppurative arthritis or for osteomyelitis.

Its radicalism is really conservative, and upon the whole it is the only method that is. It is urged against it that it proceeds upon a system, and that systematic procedure is opposed to the clinical method. That is nothing to be ashamed of; operative dilettantism has no place at the front: *the clear duty of the conservative surgeon is never to miss an opportunity for prophylaxis, and if this be a system, then the system is good.* Is it not equally systematic to give to all the wounded without distinction an injection of anti-tetanic serum to ensure protection against tetanus, which is certainly much less frequent than gangrenous and putrescent sepsis? Is it not systematic to give to all soldiers an anti-typhoid vaccination? Does medicine wait for clinical signs of diphtheritic infection, and does it wait to distinguish different degrees of it?

We need not be frightened of phrases or of recognising

boldly the necessity of a certain amount of system in the surgery at the front. The surgeon who would be conservative should never hesitate to act: he should always seek to practise those operative measures which are the true preventives of sepsis, even when there is no evident sepsis in the case before him; the true indications for them are supplied by his previous experience, which has been bought at such a price that it is unforgettable.

Thus we may accept as established the principle of prophylaxis by open operation.

It remains to determine the limits of the method. For some surgeons it only comprises one object, viz. surface drainage and the opening up of the wounded area; for them it only aims at anticipating or preventing infection; they deem it the business of the surgeon at the base to consider questions of orthopædics and restoration of function.

I cannot understand why the surgeon's obligations should be hampered by restrictions of this nature, which prejudice the interests both of the wounded and of the State.

When a projectile has split up the condyles of the femur, some surgeons say that it is only necessary to remove the fractured portion, and stop there. When a shell-splinter has fractured the lower end of the humerus and the head of the radius, they recommend the removal of splinters and do nothing more.

Have they really thought of the consequences of what they propose? Why ignore the fact that the shaft of a fractured bone in contact with a cartilaginous surface will unite with the latter with difficulty and will only do so after the disappearance of the cartilage as a result of inflammation? Would it not be simpler in the first instance to saw off the layer of cartilage which is doomed to destruction and endeavour to obtain ankylosis between the femur and the tibia by first intention?

Why forget that the joints have a normal arrangement that is not altered with impunity ? Is it not recognised that a joint whose arrangement is altered can no longer act normally ? An elbow, the surrounding structures of which have been destroyed, will certainly not function properly, and thus in the end the surgery characterised by doing as little as possible will not have proved to be conservative ; it will have been bad surgery.

It is our strict duty to do more and better than that to our wounded if it be possible, which it undoubtedly is.

In reality far above these orthopædically insufficient operations, which justify the appellation of opportunism, there exists a well-thought-out articular surgery, governed by an exact knowledge of the injuries and of the course they will take, and in accordance with the soundest precepts of peace-time orthopædics, such as Ollier has formulated. According to it, the preliminary incision of war-wounds serves for exploration and is intended to take exact stock of the local injuries and to permit of their logical treatment ; it facilitates the early removal of foreign bodies (missiles and fragments of clothing) which are causes of infection, and of the more or less adherent splinters of bone which are sources of osteitis ; it allows the straightening out of the bony injuries, as well as the resection of fractures involving the joint ; thus following out the established rules of surgical orthopædics which warfare has been unable to change.

Those who are ignorant of the principles of this surgery and whom war wounds have taken unawares, will gradually discover them anew in the deformities of their patients. It would be easy for them to avoid errors and uncertainty, by reference to the authoritative work of Ollier.

An excellent joint and a satisfactory restoration of its function can be obtained by conforming strictly to

his principles, by laying bare joints by means of incisions alongside the tendons, by sacrificing nothing that might be useful to the mechanism of the articulation, by working subperiosteally, and by first resting and afterwards moving the different parts of the limb under treatment.

It is said, however, that this method is not applicable to war-wounds because it is too delicate and because it needs experienced surgeons ; because it is not easy to preserve the periosteum free from inflammation, and because resections necessitate too much after-care. But these are bad reasons. Surgery can only be performed by surgeons of experience : the difficulties are rather those of deciding the indication for operation than the operation itself. There are not two kinds of surgery, one for the ignorant and the other for the skilful. It is easier to do a resection of the elbow well than to operate suitably upon a wound of the abdomen caused by shell-splinters ; yet no one raises objection to laparotomy on the score of its difficulty. It is simpler, and more within the reach of everyone, to do a correct resection of the knee than to decide whether to preserve a limb or to amputate in a given case : the two courses are separated by the difference which exists between what one is able to learn in a book and what is a matter of experience.

It is still said that the bony injuries in war-wounds are too irregular and too extensive to justify physiological treatment which is suitable only for the minor injuries of peace time ; that operations for this purpose would demand too great sacrifice of tissues and would give bad functional results. What a fine example of sophistry ! If the injuries are too considerable to be resected usefully, amputation is often necessary, and then the function of the limb is much more completely lost.

But according to my experience it is rarely that one is called upon to make use of resection. The objection

is consequently not justified ; but if it were, it would be necessary to conclude that resection should be reserved for limited injuries, while as a matter of fact it is exactly in the cases of severe destruction that one is able to see the indication for its adoption. The truth is that the objectors do not know how to do resection according to the tried technique which served to establish its value ; they do not wish to follow tradition ; and they imagine that they are inventing the very incisions which Ollier rejected thirty years ago as too mutilating ; they divide tendons, turn the soft parts off joints without hesitation with a bistoury ; they remove the ligamentous structures with a blunt scraper, quickly replaced by a bistoury ; they do not try to preserve a periosteal sheath : in short they perform operations which are execrable and contrary to physiological principles, the results of which can only be bad, as they were forty years ago.

Instead of condemning resection on the results thus obtained, the operation must be judged by the experience of surgeons who have had good results, and we must try to teach those who do not know them the proper technique of the operation and the necessary after-treatment. By conforming strictly to this technique both during the operation itself and in the after-treatment, we shall see a great change in the future of those whose joints are injured. Well operated upon at the front, they will find when they reach the base the active care which alone will procure for them the restoration of the use of their limbs to which they are entitled, without relapses due to painful inflammation, and without prolonged suppuration and obstinate sinuses.

Prompt surgical methods exactly adequate to the injury have this enormous advantage over the other methods of treatment, that nothing harmful is left in the wounds, which have been mechanically disin-

fected and are quite clean; thenceforth the local symptoms are extremely mild; the patients are cured under simple aseptic dressings as rapidly as they are in times of peace, without accidental infections and tedious after-effects.

The reader will be surprised perhaps that I have not recommended in this treatise the use of any antiseptic. I have not done so because, in my opinion, none is really necessary if the surgical treatment has been carried out correctly; the immediate exposure of all the recesses of a wound, the complete mechanical clearance which removes at once the missiles, foreign bodies, splinters of bone, and the sloughing tissues, as well as those about to slough, is sufficient to ensure asepsis in the wound and prophylaxis against severe infection: in this manner one obtains in a few days without chemical means or lavage the clinical asepsis necessary for the natural and rapid progress of healing. This is obtained without suppuration if the operation is done very early, and with only a mild transient suppuration if the operation is done without much delay; if the wound has become infected, exposure to the air with the same precautions, viz. complete removal of foreign bodies and sloughs, suffices to arrest the phenomena of infection without need of an antiseptic, and usually allows a cure to ensue. The experience of military surgery has taught me that infection arising in a wound never develops if the latter is fully exposed, and that exposure to the air is the only really efficacious method of checking it altogether. I am confident that it is the first, indeed the only active one among the usual antiseptics; without exposure of the injured parts, the best antiseptics are powerless; when used in combination with exposure to the air all of them appear to be active, and what is in fact the effect of the incision is attributed erroneously to the supposed power of the antiseptic.

Purely aseptic surgery is therefore the rule.

On the other hand, I press the claims of early and methodical use of physical agents, of sunshine, of hot air, and of open-air treatment, which marvellously accelerate the disinfection, repair, and cicatrisation of wounds. Sunlight therapy especially, when it is possible, ought to form an integral part of the treatment of joints: it acts like magic upon wounds, it preserves the tonicity of the muscles, and when the time for active movements arrives, the functions are regained with much less effort than after any other method of treatment. Its action is a vital one, a local biological stimulus, and one cannot employ it too much.

In short, the general principles upon which this work is founded are as follows: early operative measures performed systematically on prophylactic grounds, and sufficiently extensive to permit methodical and complete exploration of the wound; open treatment of injuries according as they affect the future mechanics of the joint; aseptic dressings; sunlight and aëration of wounds; post-operative treatment upon very carefully regulated lines.

But all the wounded cannot be treated in this manner: there are some who are only picked up late and arrive at the ambulances at the front in a frankly septic condition; others, who have been evacuated without having their wounds cleaned, have to be operated upon too late for any possible prophylaxis; still others, who have not been operated on because of press of numbers, have escaped infection and arrive at the base with an injury which is to all appearances mild. These different categories of the wounded require quite a different method of treatment from that which is applicable to the cases that have been seen early.

This is why, in connection with each variety of wound, I have indicated separately the treatment suitable for cases seen at a later date. I attach great

importance to this distinction ; it dominates all the problems of military surgery. There is a great difference between the wounded at the front and those at the base. It may almost be said that the condition of the wounded varies with the échelon of the Army Medical Service in which they are met with.

In order to make these different points quite clear, the following six headings will be treated of in connection with each joint :

1. The anatomical types of joint injuries and their clinical development.
2. The therapeutical indications at the front in the first twelve hours.
3. The technique necessary to secure a useful limb.
4. Post-operative treatment.
5. The conditions under which patients should be evacuated.
6. The treatment of cases seen secondarily or at a late period after the receipt of the injury.

This classification is perhaps not very didactic, but it is clear, and corresponds to the several problems which the wounded present to the surgeon.

Perhaps criticism will be directed to the unequal treatment of certain subjects and the frequent repetition of certain principles. I have insisted strongly on the points which appear important to me, and I have neglected others which I consider to be better known. I have related what I have seen, what I have done, what I should do, and I have tried to justify my opinions. So doubtless the contents of this little book will sometimes excite opposition. That is only to be expected of a book of its kind. But it is addressed to surgeons who have daily to solve for themselves problems which are still in dispute. I have given them my views. It has appeared to me advisable to furnish them at the same time with the principles necessary for the formation of a critical judgment and a fair

trial of a method which is productive of good results. I feel sure that their success will quickly justify the indications I have given.

To support my arguments I have reproduced a large number of original radiographs. They will be useful as clinical examples. The process of reproduction employed follows the originals very clearly and faithfully. The plates which show the functional results have been drawn from nature or from photographs with great exactness by M. Rudaux.

The plaster appliances recommended have been drawn by him from those in use upon the wounded under my care; they have been devised by my assistants, Mme. Abadie and MM. Robert and Delitch. There are many other excellent types. I have advised the use of these very simple ones because I have had experience of them. They have proved sufficient for my purpose in all cases.

THE
TREATMENT OF FRACTURES

VOL. I
FRACTURES INVOLVING JOINTS

CHAPTER I

GENERAL CONSIDERATIONS UPON WOUNDS OF JOINTS, THEIR GRAVITY AND THEIR TREATMENT

I. Gravity of Wounds of Joints

WOUNDS of the joints, which in civil practice have always had the reputation of being very serious, are among the most formidable injuries which the surgeon at the front is called upon to treat. It may be added with truth that they are perhaps those for which most can be done if he intervenes in time.

Their gravity is due to three causes.

(*a*) The projectile which strikes the patient carries with it some particles of clothing which it deposits in the joint whether it remains there itself or whether it passes out again. These particles carry various germs which there find conditions perfectly suited to their rapid development, since they are shut up in a closed cavity sheltered from everything which might hinder their growth.

(*b*) The damaged synovial membrane, which is highly absorbent, has numerous folds and recesses in which the virulence of the microbes increases the more rapidly because the recesses are shut off from the exterior, and hence the microbes are not amenable to exposure to the air, which is essential in the treatment of all septic wounds.

(*c*) The synovial injury is almost always complicated by a fracture of the articular surface. Doubtless pure synovial injuries are to be found, either with or without the presence of the missile. In the knee such a condition is not rare, but everywhere else, even in the shoulder, it is quite exceptional; practically, a joint injury is almost synonymous with a fracture of the joint. Even in the knee bony injury is always to be expected and considerably aggravates the prognosis; arthritis is then conjoined with osteomyelitis, for the fissures extending up into the shaft carry the infection for a long distance, and if the patient escapes severe early infection he is very likely to die of chronic septicæmia.

Only one type of joint wounds remains almost always uncomplicated by these formidable conditions: the bullet wounds with punctiform openings run a course similar to that of injuries not exposed to the air. A long-range bullet of high velocity only makes an almost imperceptible skin wound, meets the body point foremost, passing through the clothing without taking anything with it, and perforates the tissues without producing the great explosive damage which bullets fired at short range so often do. The wounds thus made generally remain aseptic.

In all other cases there is nearly always grave joint sepsis which develops in one of the following three principal types:

First Type of Joint Infection.—The sepsis spreads with frightful rapidity. In a few hours the temperature reaches 40° C. (104° F.), the general con-

dition is bad; the patient appears profoundly toxic. The joint is distended and very painful, and the whole limb is œdematous. Death ensues in three or four days from septicæmia, with or without gangrene; secondary amputation or disarticulation rarely saves one-third, certainly not one-half of the patients.

SECOND TYPE OF JOINT INFECTION.—One sees here the development of septic local phenomena of increasing gravity. The limb presents marked œdematous swelling, the joint is swollen, hot, and very painful; the least movement makes the patient cry out, and there are foul sloughs on the wound and a sero-purulent discharge oozes from the wound of entry, about which there is often localised gas crepitation. The temperature oscillates markedly and the general condition is profoundly depressed. One operation after another may be performed, each too late. If the knee, the hip, or even the shoulder be the joint concerned, the mortality is high in spite of amputation; the case runs its course in from eight to ten days.

THIRD TYPE OF JOINT INFECTION.—Here the injuries are limited. There is copious suppuration with purulent tracks communicating with the joint; if nothing be done, a chronic septicæmia supervenes. In the case of the shoulder, the elbow, and the ankle, repeated incisions and the removal of bony fragments generally succeed in keeping the complications under and the patient slowly gets well with an ankylosed joint. In the case of the knee and the hip, amputation and death are frequent. Patients who have apparently recovered are liable to numerous risks, such as recurrent articular osteitis, bone abscesses, and persistent sinuses.

This last clinical type is the one seen almost exclusively at the base; it and the bullet wounds with small openings comprise the forms of joint wounds most frequently seen by many, and that is why some surgeons at the base hospitals have got it into their heads

that wounds of joints are not grave. No view could be falser or more dangerous, for it leads to the advocacy of treatment at the front which is inadequate for the severely wounded, and to the proscription of the really conservative methods as being too severe.

It can never be too often repeated that it is a long way from the aid-post to the base hospital; those who arrive at the latter with an articular fracture are only those who have been able to bear the journey; the worst cases have been left behind at various stages along the route. To take account only of those who arrive at the base is to omit two-thirds of them at least.

This is directly proved by statistics.

In examining the figures of the wounded who were evacuated from the aid-posts of one division during the winter of 1914, I made a point of noting the different degrees of gravity of the wounds which I saw, and here are the results. Of 614 wounds of the upper limbs, 457 were considered fit for immediate evacuation; 157 called for immediate intervention.

Of 601 wounds of the lower limbs, 451 were apparently slight, and 150 required operation on the spot.

Thus, out of 1,215 wounds of limbs, 908 were evacuated from the front and 307, or a quarter, did not leave the ambulances in the immediate battle area.

The 908 who were considered fit to be evacuated during the first few hours after being wounded only quitted the army zone the evening of the next day, after a whole day's journey and after having passed through three successive surgical lines, where a great number of them were retained because their wounds had become aggravated or their pain had become worse. Those who reached a base hospital after a two or three days' journey were only slight cases in comparison with those who had been left behind en route.

Among the 307 wounded who required immediate surgical intervention, there were obvious joint injuries in more than a third. It will thus be seen what reliance is to be placed upon the opinion of those at the base who think that they receive wounded *straight from the front.*

Here are a few more figures :

At the beginning of November my ambulance received in thirty hours 489 wounded comprising 251 injured limbs, of which 178 were caused by bullets and only 83 by shell-splinters.

Of 138 wounds of the upper limbs, 36 were detained (29 bullet wounds, 7 by shell-splinters), and 102 were considered fit for evacuation from the zone of the divisional ambulances (74 bullet wounds, 28 by shell-splinters).

Of 123 wounded in the lower limbs, 79 were evacuated (58 bullet wounds, 21 by shell-splinters) and 44—more than one-third—were detained (27 bullet wounds, 17 by shell-splinters). Half of the wounded detained had evident joint injuries.

On the night of December 24-25 we received 150 wounded. Among 43 having injuries of the upper limbs, 15—*i.e.* 28 %—presented fractures of the shaft or articular ends, and were treated on the spot. Among 27 having injuries of the lower limbs, 13—or almost 50 %—presented fractures of the shaft or articular ends, and were not evacuated. These few figures enable one to understand how greatly mistaken is the calculation of those who judge the real gravity of joint fractures by what they see at the base.

In dealing with war-surgery it is always necessary to be precise as to where the operation is performed when one talks of the nature of the surgical procedure, for there is a fundamental difference in the gravity of the wounds seen at a station situated half an hour's journey from the line of fire and those seen twenty-five miles behind ; and much more between those received

by the divisional ambulance and those which arrive at a base hospital after two or three days of successive transfers. Since the conditions are not similar, treatment that would appear conservative at the base is not so at the front because it would be insufficient, while an operation that would be thought conservative at the front might appear too radical at the base.

It is owing to their inability to draw this necessary distinction that some surgeons have proclaimed the failure of conservative surgery, while others, with a like conviction, have been able to recommend systematic abstention from operation and advise immobilisation pure and simple, as was advocated in military surgery before the present war.

For the surgeon at the front who has to sort out his patients without delay, articular fractures fall into three large groups :

1. Crushing of a Limb in the neighbourhood of a Joint.—Here there is a smashing-up of the bones and joint accompanied by extensive destruction of muscles and irreparable vasculo-nervous injuries, for which amputation or disarticulation is alone of any use. The best time to perform the operation is the only matter open to discussion in these cases.

The injured arrive in a condition of extreme shock. None of them are evacuated from the front line; unless there is an enormous number of cases, none are passed through to the 2nd Ambulance station, much less the clearing-station ; they do not get past the first surgical line (*relai*). Whatever be the treatment, whether by immediate or delayed amputation, the mortality is considerable. This might perhaps be diminished by performing transfusion of blood before operation, if this were possible, and it might well be tried.

But to conditions such as these the name of joint-wounds is inapplicable, and to include them in the same category as those in which the joint injuries are

more or less uncomplicated is to create confusion. It will not be done here.

2. COMMINUTED ARTICULAR FRACTURES WITH OR WITHOUT FISSURES RADIATING INTO THE SHAFT, BUT WITH THE MAIN VESSELS AND NERVES INTACT.—This is the group comprising wounds of medium severity which form the great majority of joint fractures. There are all degrees between the complete destruction of a joint on the one hand and the simple parietal fracture of an articular end on the other. The treatment of these will be discussed almost exclusively in this book. In the case of each articulation I shall consider the treatment of a joint wound without fracture, with or without the missile present.

3. BULLET WOUNDS OF JOINTS WITH A PUNCTIFORM SKIN WOUND, WITH OR WITHOUT FRACTURE.—These behave like simple fractures and are quite mild in character, provided that rigorous immobilisation is secured. They are really punctured wounds of the synovial membrane, simple trochar-like wounds of the bone with or without radiating fissures of the shaft, and they result from long-range bullet-wounds.

In the case of the knee, a copious hæmarthrosis often requires one or more aspirations which it is well to make quite early. Otherwise prolonged immobilisation alone suffices for cure, but it must be kept up for a long time and movement must only be commenced when all pain has completely disappeared.

I have had 12 cases of this kind—7 of the knee, 3 of the shoulder, and 2 of the elbow; they wore a plaster casing for from three weeks to two months. They all recovered, with very satisfactory recovery of the functions of the joint.

Briefly, these cases are of the mild type which before the war was considered the usual type of bullet wounds of joints. Their mildness is explained by the conditions under which the wound is made; the bullet enters with its pointed end foremost, passes through

the clothing between its threads without carrying any with it. It traverses the skin, the muscles, and the synovial membrane without depositing in them any infected fragments of clothing, and the fracture, whatever be its type, whether erosion, cartilaginous abrasion, furrow, gutter, or bony perforation, is an aseptic fracture, and runs its course as such without infection.

But no rule is absolute, and one can quite well understand that infection may occur in these joint wounds with tiny skin orifices. So these patients ought always to be very carefully supervised ; their temperatures should be taken regularly, the joint should be examined daily without necessarily removing the plaster each time. If after the first few days the primary fever caused by the hæmarthrosis persists, if the temperature, after having fallen to normal, suddenly goes up, if the general condition is affected, or if there is the least suspicion of infection, free arthrotomy may become necessary. I have never had occasion to perform it under these circumstances.

All the foregoing remarks about joint injuries with punctiform skin wounds refer to the injuries made by bullets. In the case of quite a minute wound caused by a small splinter of a shell or grenade, infective complications are to be feared. The wounds made under these circumstances resemble those in the second category above and will be considered with them.

II. General Treatment of Wounds of the Synovial Membrane and of Compound Fractures into Joints

Since the crushing of limbs in the neighbourhood of joints requires amputation, and bullet wounds of joints with very small skin wounds are amenable to simple immobilisation, there is only a single category of joint wounds in which the treatment is varied and

open to discussion. It forms our second group and is a very large one.

Before seeing what it is best to do for one of these cases it is well to define the principal types which can be identified by radiography.

They are, in order of increasing anatomical gravity :

(*a*) A wound of the synovial membrane, without a bony lesion but with the projectile free inside the joint ; this is rarely seen except in the knee, and is very exceptional elsewhere (*e.g.* the shoulder).

(*b*) A wound of the synovial membrane with the projectile embedded in bone, that is to say with a fracture of the cancellous end of one bone.

(*c*) A wound of the joint with a fracture of the compact layer of the epiphysis, that is, a fracture not interrupting its continuity. In these cases there are sometimes fissures and multiple jagged splinters.

(*d*) An articular fracture properly so called, single or multiple ; here the bony lesions vary very much according to the epiphysis affected and the circumstances governing the impact of the projectile. In the case of the upper end of the humerus there may be a simple separation of the head, or complete destruction of it, a frequent type ; at the elbow there is often a T-shaped fracture with irregular fissures, recalling in certain points the fractures of civil practice ; the articular fragment is often large, the shaft being pointed like the mouth-piece of a flute. In the ulna, besides a transverse fracture of the olecranon, complete crushing of the bone into small fragments is met with. The same thing may occur in the head of the radius where large splinters are rare.

In the hip, crushing of the trochanter, with fissure through the neck, or separation of the head of the bone is frequent.

In the knee, simple fracture of one condyle or a T-shaped fracture (figs. 2 and 4) of the femur may be found ; in the tibia, it is common to find extensive

crushing of the cancellous tissue with pulverisation of bone, but without large splinters or radiating fissures (fig. 3). Radiating fissured fractures are especially often met with in the lower extremity of the humerus, in the ulna, the hip, and the lower end of the femur.

(*e*) Complete crushing of the articular end.

This classification makes it clear that one standard method of treatment is not applicable to all cases.

But the fundamental principles of treatment remain irrefutable ; they are those which govern the entire treatment of war-wounds, that is to say, the necessity of a primary clearing operation, performed as early as possible, removing missiles, fragments of clothing and organic débris on its way to rapid decomposition. There can be no question as to the absolute urgency of these preventive incisions, which are prophylactic against sepsis and are the basis of all conservative surgery.

This clearing out by incision ought to be complete, extend to all the injured parts, and leave nothing doubtful behind.

In practice there are still differences of opinion upon the best way of carrying it out and the extent to which it should go.

We have the choice of four methods—viz. arthrotomy, removal of bony fragments from the joint (esquillectomy), resection, and amputation.

These operations are in no way opposed to one another ; each has its indications, which are determined by the extent and nature of the injury as determined by radiography and by exploration. On the other hand, the indications vary according to the time that has elapsed since the infliction of the wound and according to its situation.

A. Primary Operations (during the first twelve hours). —Theoretically we may say that to effect with certainty the necessary prophylaxis and to make sure of a definite orthopædic result, it is necessary in the

first twelve hours to extract the missile, to remove fragments from simple parietal fractures, to resect those fractures which interfere with the mechanics of the joint, and to amputate for conditions in which the damage is incompatible with the ultimate satisfactory functional restoration of the limb.

In practice these are the rules which ought to be applied as soon as possible, certainly within twenty-four hours.

(*a*) *Missiles within the joint must be removed.*—There are no doubt some which remain clinically aseptic, but they are quite the exceptions. As a rule, a splinter of a shell or grenade, carrying with it débris of clothing, is followed with certainty by a rapidly spreading acute arthritis. The infection introduced into a closed cavity is very formidable, and a fatal result often follows. In short, the presence of a missile in a joint is always dangerous. Its removal is quite the opposite.

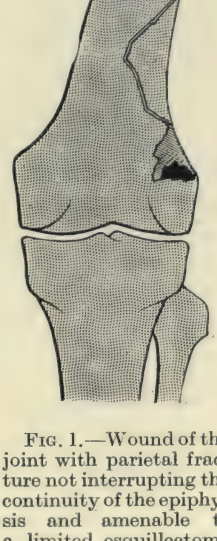

FIG. 1.—Wound of the joint with parietal fracture not interrupting the continuity of the epiphysis and amenable to a limited esquillectomy after removal of the projectile.

Simple opening-up of the wound is not sufficient to eliminate all chance of sepsis; drainage certainly diminishes the immediate risk of its development, but unless the missile be removed, the degree of infection is only lessened and the patient remains a prey to slow septicæmia which is sometimes fatal.

(*b*) *The area of a parietal fracture should be excised.*—Every bone which is fissured or frayed at the edge and all crushed cancellous tissue ought to be treated

by scooping out the bone and removing the bony splinters ; on the points of these, even after extraction of the missile, minute organic particles and threads of clothing material are held up, and the development of a focus of osteitis is a grave matter. This osteitis is the more dangerous as bony fissures often radiate from the point which was struck, and the

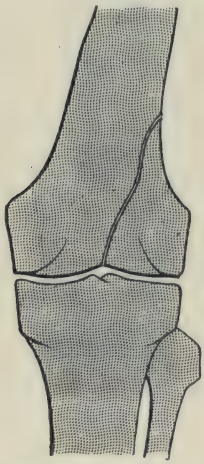

FIG. 2.—Fracture of one condyle requiring, in view of future orthopædy, resection of the knee-joint through the epiphyses.

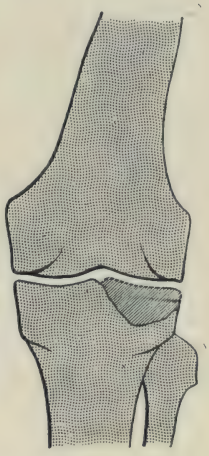

FIG. 3.—Fracture of one condyle of the tibia requiring, in view of future orthopædy, resection of the knee-joint through the epiphyses.

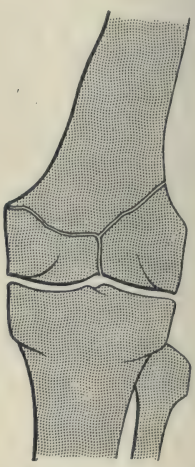

FIG. 4.—T-shaped fracture of the lower end of the femur requiring typical resection of the knee-joint.

sepsis travels along these. As a result, infection of the bone marrow occurs which amputation alone is able to remedy.

(*c*) *A fracture that will permanently interfere with the functions of a joint should be treated by immediate resection,* chiefly because that operation in the very early

period guards against infection ; and also because it provides for the future usefulness of the joint except in the case of the knee, where ankylosis ought to be systematically aimed at ; elsewhere it assures satisfactory if not entire, recovery of function, while at the knee it is the only measure that assures a position of the limb which is fundamentally necessary to walking (figs. 2–4).

But for this purpose resection must be as true to type as possible : it ought not to be merely a question, as it often is, of the mere level of the bone sections. The typical operation is that derived directly from the teaching of Ollier, and deals with the joint without sacrificing the tendons, carefully separates the periosteal prolongation of the capsule without dividing ligaments or tendons, and is followed by a most strict post-operative treatment.

(*d*) *A fracture of the lower limb extending as far down the shaft as it does towards the epiphysis should be treated by amputation*, because a cure is difficult to obtain by conservative methods and would be followed by a very bad functional result (fig. 5).

In the upper limb amputation is to be avoided at any price short of extensive excision of bone, however little hope there is of preserving a useful hand.

To these general statements we may add that :

(*a*) *Arthrotomy* in the early stage ought to be only an exploratory procedure followed by extraction of the missile, which should be localised if possible. The best method of localisation would appear to be Hirtz's "compasses," when there is time to employ them ; if stress of work will not allow of this, the position of the projectile should be ascertained by radioscopy, marked on the surface, and the joint widely opened. If radioscopy is not available, an exploratory arthrotomy should be performed so as to admit of removal.

(*b*) *Esquillectomy* (*removal of the fragments*) will be added to arthrotomy whenever the bony lesion is

confined to the surface of the bone. It should be done by a rugine followed by a curette. If the fracture is more extensive than at first appeared or than is indicated by radioscopy, if, for example, there be deep-seated cancellous crushing of one of the condyles of the femur, one would perform immediate resection; "esquillectomy" * is only of use in the small parietal fractures. They are, in my opinion, the only cases suited for this method.

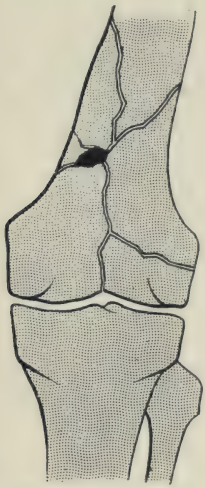

FIG. 5.—Fracture of shaft and epiphysis necessitating amputation.

Many surgeons take a different line: arthrotomy with esquillectomy is with them the treatment of choice for almost all fractures into joints, because it appears to be the most conservative method. They contrast it with resection, which they say gives bad results and look upon as a mutilating operation. According to their view, arthrotomy is done to drain an area that esquillectomy has cleared out. Thus presented, the parallel is absurd; each operation has a precise field of its own, which cannot be departed from without falsifying the results and the indications.

In the early stages of these war-wounds arthrotomy ought not to be done to drain, but to explore, so that the surgical sterilisation of the wound may be ensured by the removal of foreign bodies; if the missile in its passage has caused a partial fracture, a gutter or furrow on the articular end, if it has detached a frag-

* The term "esquillectomy" will be used throughout this translation instead of the more cumbrous term "removal of splinters of bone."—ED.

ment or splinters of bone, the removal of these also is indicated ; and the same is the case when the missile has embedded itself in the bone and has produced in it a crush-fracture. But whenever there is definite solution of the continuity of an epiphysis, esquillectomy ought to give place to resection. One can doubtless recall some brilliant results from limited intra-articular esquillectomy in these complex cases, but these will always be exceptional results obtained under favourable circumstances : the method is dangerous, because patients in great numbers cannot all receive the strict supervision which is imperative for success ; besides, the final orthopædic result of these partial operations is generally bad.

(*c*) *Subperiosteal resection* is the method of choice for comminuted epiphysial fractures likely to unite badly, and for all those that interfere with the mechanics of the joint. If done early, it is the typical operation for the prophylactic clearing-out which anticipates all sepsis and ensures aseptic results. When done according to the subcapsular-periosteal method, it gives remarkable results. It is used more freely in some regions than in others ; at the shoulder it will sometimes be possible to do without it, subcartilaginous excision giving very favourable results. At the elbow, at the knee, at the ankle, and in the metatarsus it should, however, always be employed ; in these situations it is the ideal conservative operation.

(*d*) *Immediate amputation* ought only to be chosen in exceptional cases, unless there is crushing of the bones with irreparable injury to the muscles, vessels, and nerves.

In the upper limb it ought never to be performed primarily whatever the extent of the injury, because subperiosteal resection and extensive esquillectomy always suffice to deal with even the greatest damage.

In the lower limb it is performed sometimes after direct exploratory examination.

Whatever may be the state of the elbow or the shoulder, a normal hand with mobile fingers is always of more use than a hook on the forearm. In the lower limb, on the contrary, the conditions may be such that an artificial leg is much better than a considerably shortened leg or thigh. One can hardly define these conditions in words ; it is largely a question of degree. Three factors, however, dominate the decision :

If the lesions of the soft parts are very extensive, if, in short, preservation of the limb appears too hazardous, immediate amputation should be done.

If the bony lesions are too extensive for the functional power to be ultimately restored, one would amputate at once ; in practice, any injury may be considered as too extensive that would entail a shortening of at least 4 inches.

When there is a great influx of wounded, amputation should be chosen unless the case appears very favourable for resection ; conservative surgery requires diligent post-operative supervision, much time and care. Without them it is dangerous and apt to lead to disappointing results.

B. Secondary Operations (in the febrile period).— In these cases there is no longer any question of practising prophylactic operations upon damaged areas threatened with imminent sepsis, but of ensuring drainage and rapid disinfection of an already infected joint. The decision as to the operative measures best fitted for this purpose is guided by the question of the resistance of the individual patient ; the longer the time since the commencement of the sepsis, the more radical should the measures be, and the less the reliance that should be placed upon drainage without removal of bone.

(1) *Arthrotomy* is suited to pure synovial injuries, to drain abscesses, and to remove if possible the foreign bodies causing the trouble. It is useful for joints

with loose capsules and large synovial cavities. It only drains close-fitting joints like the elbow and the hip indifferently. It is only successful in cases of joint suppuration due to superficial osteitis that easily finds its way to the surface. It should be employed for the shoulder and the knee, elsewhere it is not worth while wasting time upon it ; the less so since the usual result of these suppurations is ankylosis, and it is therefore better to resect at once, especially where articular mobility is desirable, as for example in the elbow.

(2) *Resection* is a method of drainage only in the close-fitting joints. In severe infections without fracture it performs marvels at the elbow, the wrist, the hip, the ankle, and the tarsal joints. Often useless at the shoulder, it is equally so at the knee, since it leaves no cavity for drainage. In simple suppurating arthritis of the knee, without injury to bone, if arthrotomy with extraction of the missile does not lead to rapid improvement of the general and local phenomena, and if at the end of three or four days the condition is still critical, resection is useless and even dangerous. Perhaps excision of the synovial membrane might be of value : I do not recommend it since I have no experience of it, and until we have more knowledge on the point we must resign ourselves to rapid amputation.

It is quite a different matter when there is a fracture. The infection is then rather an osteomyelitis than an arthritis, and it is safer to resect at once, even at the knee, to get rid of the infection. Undoubtedly failures will occur, but there will also be remarkable successes. My advice is to use it immediately for any joint unless the injury is parietal or extra-articular.

(3) *Immediate amputation* is called for when the patient's general condition is profoundly lowered, when there are purulent sinuses everywhere, and when there are multiple infected wounds ; in short, when the patient obviously requires to be rid at once of the source of the infection.

Secondary amputation should be done, without too great loss of time, for injuries of the knee after the failure of arthrotomy or resection, the risk of the septicæmia being then only too apparent. In the case of the ankle and the upper limb an attempt to preserve the limb by resection can be persisted in much longer without danger.

III. General Technique of Operations upon the Joints

The operations which are performed on the joints, being essentially conservative, require great precision and much attention to detail from beginning to end. The different operative stages should be conservative, in order that the final result may be preservation. It is a fundamental precept, never to be forgotten, that whenever an attempt is made to obtain recovery of function, none of the elements of strength and mobility in a joint must be sacrificed.

This precept imposes two rules of technique which ought to be regarded as dogmatic.

The exploratory incisions should not sacrifice any tendon, muscle, or muscular nerve-supply.

The opening up of bony cavities ought to be done with the sharp rugine, which not only separates the periosteum, but raises with it the capsular ligaments and tendinous insertions, thus leaving intact all the working apparatus of the joint.

I place on record these two precepts of Ollier's conservative surgery because many surgeons do not know them or have not understood the bearing of them, which will explain the want of functional success which is wrongly attributed to resection. These surgeons have regarded the preservation of the periosteum as the only point in Ollier's method, and since the osteogenetic power of the periosteum is not always necessary, and as from this point of view it is possible at times to do without it, they have concluded that

its separation is a useless complication, and have returned to their former extra-periosteal (parosteal) methods.

This is an absolute misapprehension of the conservative method, as we shall see.

1. Physiological Incisions.—In 1885 Ollier wrote as follows: "The object is to preserve all the tissues, all the elements essential for the reconstitution of the bones and the joints, while causing the least possible damage to the peripheral organs. To attain this end we must do our operations by methods different from those in ordinary use. One should approach a joint in the same manner as one approaches an artery, namely, through carefully planned incisions. There is no longer any call for rapidity in opening a joint: it should be approached by way of the muscular interspaces without injuring any structure not only important, but merely useful, and without sacrificing any of the requirements of a sound operation, such as room for the operator and space for the movement of his instruments."

These intermuscular incisions are made only in certain well-defined anatomical situations when an arthrotomy or resection is in question. The incision appropriate for each joint, "*the physiological incision,*" is given farther on; it is the incision chosen with due consideration for the future physiological function of the joint.

In war-wounds it may seem impracticable to follow these lines: one will often be tempted to utilise the openings made by the missile. Whenever these are not gaping holes, however, it will be an advantage to approach the joint by the correct route and to utilise the track of the missile, after it has been duly cleaned up, as a route for draining, and not as a means of access. That is a question of dexterity and common sense which cannot be reduced to rules. If it is decided to utilise the existing wound, its walls ought to be

excised with a bistoury so as to transform it into a passage with clean sides without unduly sacrificing healthy muscular tissue. Muscles and tendons ought not to be divided transversely by joining the two openings of a sinus ; in the case of the shoulder particularly, division of the deltoid is disastrous. In a word, a joint ought always to be approached with a full regard to its future movements.

2. Preservation of the Capsulo-periosteal Sheath.—This ought to be preserved, for two reasons : first, to retain the elements essential for regeneration of bone, which is the anatomical aim, so to speak ; second, to maintain intact the factors concerned in the stability and mobility of the joint, the physiological aim.

(*a*) The whole thickness of the periosteum with its deep osteogenetic layer ought to be preserved because, thanks to its activity, the bony extremities are regenerated.

What happens after a resection ?

At each end of the capsulo-periosteal sheath at its periosteal edge, the osteogenetic layer proliferates, thickens, and gives rise to masses of soft consistence and cartilaginous appearance, in which ossification occurs. Two masses of new bone result, which soon constitute new articular extremities between which a new joint is formed.

(*b*) The capsular sheath ought to be preserved because one thus retains inside it a certain number of endothelial cells which favour the creation of a new synovial membrane, and outside it the necessary ligamento-tendinous continuity.

Let us consider first the formation of a new synovial membrane.

At the edge of the capsular portion where the synovial membrane exists, the serous layer thickens under the influence of traumatism ; its endothelial layer sends out cellulo-vascular processes which meet one another

and, blending together, form what will become later the articular cavity.

If the wound does not suppurate, or only does so slightly, we have at hand all the elements necessary for that gliding motion which it is the object of gentle movement to promote during the early stages of the organisation of the wound. Little by little, under the influence of these movements, the endothelial lacunæ enlarge, the partitions wear away and disappear, and finally a new synovial membrane is formed : that is the ideal plan of development.

When, on the contrary, inflammation or operative measures have destroyed these synovial elements, it is much more difficult to form, by means of repeated gliding movements, a sort of hygroma, or an inter-osseous serous bursa, and this is always less perfect and less adapted to its purpose than is the true synovial membrane in the former case. After this explanation it is easy to understand why technique and post-operative care play an essential rôle in the final results of resection if we regard them from the point of view of restoration of function. It is for want of understanding of this anatomico-physiological development of new joints that some surgeons only get bad results and therefore condemn resection.

If the preservation of the synovial membrane and its regeneration play a large rôle in the post-operative formation of a new joint, it is the preservation of the whole tendino-ligamentous capsule of the joint, and the retention of the muscular insertions in their normal relations to the capsulo-periosteal sheath, which causes the gradual development of the new joint towards the perfect physiological type.

The capsulo-periosteal sheath placed in immediate contact with the bone acts at first like a guardian to the process of osteogenesis ; it limits the new formation of bone, restrains it, and maintains it in good position ; then at the proper time it models it under the action

of the muscles, which, having retained their insertions into the part of the capsule corresponding to the epiphysial tuberosities, remain in their normal position and contract as usual. By their normal action they press on the capsule and make their impress through it on the newly formed bone. In other positions they pull upon and mould the soft bone into shape. In short, their action, which is retained intact by the preservation of the capsular sheath, is constantly tending towards the production of a physiologically normal joint.

The careful separation of the capsular sheath is even more indispensable when the injuries are so extensive that it might seem useless to take all this care. Here, the preservation of the tendinous insertions in the capsulo-periosteal sheath assures the functions of the muscles, permits the secondary drawing together of the widely separated bones, and rearticulates them in some measure ; the capsule then acts as an elongated tendon, and it is by its means that one is able to obtain excellent functional results in many extensive resections.

It is unnecessary to labour this point further.

What are the necessary steps in practice to preserve these indispensable factors for recovery of function ?

After the joint has been opened, as described, and the intermuscular intervals kept apart by retractors, it is necessary first to incise the capsule in the direction of its fibres, or the long axis of the limb. When that is done, the knife is abandoned for the rugine, which should be used throughout the rest of the operation. This rugine should be of a special pattern : for separating the periosteum and its sheath there is only one good one, that of Ollier, with a steel shaft ending in a flattened extremity, as sharp as a razor. This cutting edge is bevelled from its dorsal surface downwards towards the under edge which is kept in contact with the bone (fig. 6).

With this instrument, which has a solid handle, a way is made by degrees between the bone and the periosteum, and one is able to raise the periosteum and the capsule bit by bit, and to preserve intact a fibro-periosteal prolongation of the muscles and tendons. The name "détache-tendon" which Ollier gave to this instrument indicates the object in view. But in order to attain it without accidents, the rugine must be used slowly and forcibly, the right hand being guided by the left index finger applied to the right. With a little practice it is possible to denude the most irregular tuberosities so that finally the bone will be as free as if it had been enucleated from its fibrous sheath. This method is applied to each fragment of bone which is more or less free. Every little fragment, however small, ought to be treated thus; it should be grasped in forceps and its external surface carefully stripped. It is only in this way that the subperiosteal operation can be truly and typically carried out.

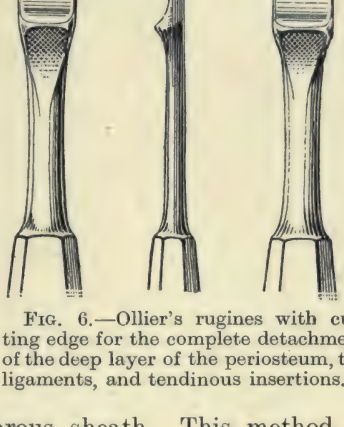

FIG. 6.—Ollier's rugines with cutting edge for the complete detachment of the deep layer of the periosteum, the ligaments, and tendinous insertions.

A final detail will perhaps be useful: as one approaches the shaft, the separation of the periosteum becomes easier. Sometimes a careless movement causes the shaft to project through the separated sheath. This is an accident which is most likely to occur in resection of the elbow when the separation is being carried above the condyles of the humerus, espe-

cially in secondary operations : it can be avoided by care.

3. Division of the Bone.—In resections it is often remarked that it is difficult to steer a correct course and remove enough bone to procure mobility without removing too much to preserve a sufficiently firm joint.

The best sections are those made through the epiphysial ends. It is much more frequently possible to do this than one would think. When these injuries are limited, there is sometimes difficulty in making the bone project sufficiently to divide it, and the surgeon may be tempted to prolong the denudation further towards the shaft : this is useless, and gives very little more room. The difficulty is caused by the periosteal-ligamentous adhesions, and should be overcome by again applying the rugine to each tuberosity, and stripping off these structures transversely instead of axially. A chain saw, or Gigli's saw, can then be used, and the epiphysis divided at a suitable level.

When the injury is more extensive and runs along the shaft, there is no need to conclude that the conservative operation is doomed to fail to restore the function of the joint, and should be rejected. In the majority of these cases the fracture in the shaft runs parallel to the long axis of the bone ; a large fragment comprising the articular end and a part of the shaft is detached, but there is no actual solution of continuity of the shaft itself. The pointed end of the latter reaches down to the level of the broken epiphysis, and the saw has only to remove this sharp extremity. If the periosteum has been carefully preserved, bone formation will result, and a new epiphysis will be constituted.

In a number of cases the epiphysis is only fractured on one side ; the broken fragment comprises a thin shell of the shaft which is of no importance ; enough of the articular end remains on the opposite side for

a unilateral intra-epiphysial section to be made which is sufficient if the periosteum has been preserved.

When both epiphyses are destroyed (*i.e.* T-shaped fracture), it is customary to find fissures extending up the medullary canal of the shaft. Unless resection is performed, these parallel fissures constitute a very

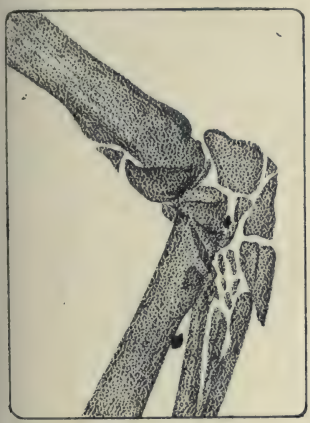

FIG. 7.—Fracture of the elbow by shell-splinters. Total resection of the elbow-joint on the second day, in consequence of the fissured shaft of the ulna.

FIG. 8.—The same case as fig. 7. Radiograph fifteen days after resection.

great danger if the bone becomes infected, because it is thus that acute osteomyelitis arises. If, however, the intra-articular fragments are removed, and the wound is systematically cleaned, they frequently weld together and reconstitute the shaft (figs. 7–9). There is no need for anxiety in these cases : the bone section should be performed as if the fissures did not exist.

If the fracture is clearly as much epiphysial as diaphysial, with its centre at the line of junction, it must

be realised that this injury often leads to amputation if resection is not performed at once. But the operation ought to have for its object the preservation of a large portion of the lower fragment of the shaft, which is nearly always possible. The articular end is removed and the limb carefully immobilised in a suitable position for five or six weeks, so that bony union, which is accelerated by the operative measures, may occur in the fractured shaft. Then, but then only, attempts at movement may be made if mobility is desired.

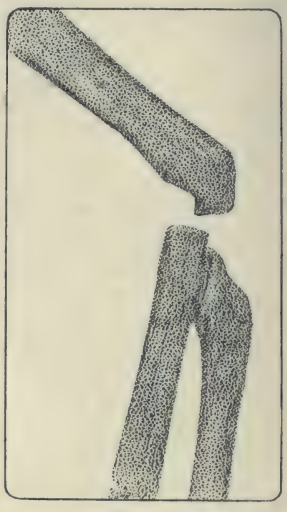

FIG. 9.—The same case as figs. 7 and 8. Radiograph at the end of two months. The wound was healed by the thirty-ninth day; active flexion had then almost reached a right angle. At the end of a year the result is perfect: active flexion and extension are normal; the patient can carry 15 kgs. with the arm raised; pronation and supination are normal.

Thus, resection in certain cases is an operation true to type, in others it consists in removal of all the epiphysial fragments, subperiosteally of course, followed by trimming with the saw.

When the articular end of one bone only is affected, should resection be confined to that bone?

This is the usual procedure in certain situations; hemi-resection of the upper end of the humerus is commonly called resection of the shoulder, and femoral hemi-resection resection of the hip. In military surgery, the classical method is adhered to at the hip and shoulder if one bone only is injured, because it is sufficient to ensure good post-

operative results, and because the functional recovery is better when it is so done.

But in other situations it is different. As a general rule, when mobility is desired, it is better to put into contact two bony surfaces, which by friction will adapt themselves to one another, than to oppose bone to cartilage, in which case the adaptation will not be so good, since the unmouldable cartilage will remain as it is, the other surface having to do all the work of fashioning the joint. At the elbow this is very clear: no doubt some perfect results are obtained from hemi-resection, but more often the articular movement becomes checked at a certain stage; in the lower hemi-resections of the elbow (*i.e.* of the bones of the forearm) the movement of active flexion beyond a right angle can only be effected after a sudden slide over the anterior trochlear surface. In the superior hemi-resections (*i.e.* of the humerus) one never restores pronation and supination. At the elbow, then, it is better to do a total resection, unless the loss of substance in one of the two bones is too great. In the resections where ankylosis is aimed at, as at the knee, there is great advantage in bringing two bleeding bony surfaces into apposition. It is illogical to allow contact between bone and cartilage if one wishes to obtain firm bony union; and besides, the removal of a thin slice of cartilage does not add greatly to the loss of substance. Thus, except at the hip and shoulder, a resection of both articular ends should be the rule.

4. Drainage.—The best method of draining a joint which has not been resected is to insert drainage tubes into small openings in the capsule. It is better not to pass them in deep, and not to insert any transversely, aseptic though they be, across a serous membrane which does not tolerate them well. In the case of the pleura, this rule is well established; in the case of the synovial membrane it holds equally well.

When the case is one of resection instead of an arthrotomy, the injuries being largely exposed, I do not as a rule put in drainage tubes, but insert tampons of aseptic gauze gently without force or pressure. Gauze is regarded as holding up the discharges, and many surgeons proscribe it for that reason. It is probable that they plug too forcibly, which makes it ineffective, or that they leave the dressings in place too long. These are questions of personal practice which are not absolute rules. The principal point is to leave the wound wide open without suturing it, as A. Poncet always advised in all surgical casualties.

5. Immobilisation.—Every joint that has undergone injury or has been operated upon ought to be immobilised. In principle, the only good immobilisation is that which fixes the joint above and that below, as A. Bonnet advised, and the realisation of this ideal ought to be striven for. After resection, however, it is not absolutely necessary everywhere ; thus in the case of the elbow it is useless to immobilise the shoulder ; but as a general rule the principle holds.

The best immobilising agent is the plaster casing. I think that at first this method should always be used (except at the elbow, where I often omit it). Metal splints ought only to be used if there is no time to make others. It is only later on that the wire splints or plaster-of-paris splints with windows are indicated. The former do not immobilise as well as the plaster casings, the latter make it difficult to inspect the limb ; Ollier abandoned them twenty-five years ago. In spite of their present vogue they should only be used sparingly for joint injuries, and even then always only temporarily.

6. Dressings and Sunlight Therapy.—After primary resection performed early, the course of the wound is uniformly aseptic. Dressings can and ought to be done seldom ; the post-operative dressing may well remain unchanged for 8 to 15 days. In

all cases one can and ought to dress the cases only occasionally unless sunlight treatment is possible.

After secondary (*intra-febrile*) resections, it is often necessary to do the first dressing as early as the end of 2 to 4 days, but after this has been done it will be advantageous to disturb the wound as seldom as possible. I have seen intra-febrile operations for the removal of the astragalus healed in 60 days after 6 dressings, some secondary resections of the elbow in 39 and 45 days with 2 dressings between the 1st and 15th days, after which the necessity of movements called for greater frequency. The current fashion then is few dressings, and, I would like to add, not voluminous ones. There is a tendency to use too much wool, to bury under enormous layers a wound which wants to be aerated, a skin which is best exposed to the air and the sun. A custom which is very expensive and particularly bad is to envelop the limb in non-absorbent wool sterilised or not.

These bad practices ought to be abandoned.

In general it is well to do the first dressing under ethyl-chloride anæsthesia ; one is able thus to remove the gauze and replace it without pain. After each dressing strict immobilisation is renewed.

If the climatic conditions allow of a sun bath, the procedure is different: insolation and a change of dressing will be the daily rule. In these circumstances a very light dressing is employed. Those who have never practised heliotherapy can have no idea of the truly magical effect of the sun on surface wounds ; in a few minutes, under one's eyes, the bleeding surface is entirely modified. A sitting of a quarter of an hour suffices to get rid of the sloughs and after three or four sittings suppuration is at an end. This result is due to a regular flow which occurs from within outwards. If the sun is rather strong, at the end of five minutes on an average one sees the wound dotted with red spots ; at the end of seven minutes

a sort of pink serum exudes having the appearance of blood serum; the flow is abundant enough for one easily to collect an appreciable quantity if one wishes. Then the wound becomes glazed; it takes on a fine reddish tint, and if touched it bleeds. In short it gives the impression that some embryonic capillaries are formed on the spot in a few moments, and that the wound is vascularised as if by some intense reaction.

At the end of some days the wound is considerably reduced in size; cicatrisation progresses with wonderful rapidity, and healing is obtained more quickly than by any other method. But insolation has yet another advantage: under its action the muscles do not atrophy but they remain strong and vigorous. When it is desired to re-establish movement in the joint the period of passive movements is much shortened; the power of active contraction is recovered in a few days. I have seen patients whose elbows have been resected move their forearms themselves fifteen days after operation. One patient at the end of forty days was able to lift $1\frac{1}{2}$ kilogrammes with arm extended, and then to raise it beyond a right angle. Heliotherapy is an expedient no one should overlook.

7. Mobilisation.—If one does not deliberately seek for ankylosis, whether after arthrotomy or resection, early movement is the condition necessary for the recovery of the functional power. But this ought not to be begun until the day after all pain has disappeared; it should only be continued if the passive movements can be performed without any acute pain and without producing inflammation. There are no other rules than these. It should never be forgotten that absolute rest and immobility form the basis of all treatment of inflammation. By not obeying this law one runs counter to the end in view.

On the other hand, if the period of immobility is

unnecessarily prolonged, the formation of bony ankylosis and firm ligamentous adhesions is favoured. It also induces a muscular atrophy that is often irremediable. It is not well, then, to prolong the period of joint-rest too far. But attempts at movement must be made very gently ; any undue force is paid for by inflammation which increases the tendency to ankylosis. In fine, if recovery of the normal function of a joint is sought for after an operation, one must avoid three dangers : too prolonged immobilisation, too rapid mobilisation, and forcible mobilisation. Neglect of this is the explanation of many failures.

Mobilisation, therefore, should be begun very gently but early, subject to the above reservations (no pain, no temperature, no secondary reaction), even if there is much loss of bone. In this case the muscles have got to take the place of ligaments in the new joint : it is essential to preserve them to the utmost. But in the intervals between the short trials of passive movement there must be complete immobility with the bones in contact.

Care is necessary not to exceed the limit : so persuaded does one become of the necessity of movements that one is apt to consider the patient who does not wish them to be performed as cowardly or hypersensitive. Either they are imposed upon him as a stern necessity, or they are done unexpectedly, which is the worst of methods. I have often witnessed the deplorable results of too much zeal. As Ollier has written, " If docility on the part of the patient should be his greatest virtue, patience on the part of the surgeon is no less necessary. It is a mistake to hope to obtain in eight days what requires several months. It is not a matter of conquering resistance and of breaking down adhesions, but of favouring the reconstitution of gliding movement and the regeneration of an interposed serous membrane. Time is indispensable for these things. Too violent or too pro-

longed exercise is capable of injuring the tissues which it is intended to make supple, and of inducing a plastic and adhesive process instead of creating a sliding joint."

By adopting these precepts one is sure not to end either with ankylosis or with a flail-joint. The latter, with its complete loss of power of active movement, is primarily due to complete muscular insufficiency and bad post-operative management. When a primary resection has been done, the muscles are vigorous and strong, nothing has atrophied them; when they contract, they press the articular surfaces closely together; they articulate the new joint and permit to it a play of movement of satisfactory amplitude and precision, even if the resection has been very extensive. Doubtless in war-wounds one should not look for the ideal anatomical result of the resections performed in peace-time with their perfect restoration of the bony extremities in their normal position bound together by a marvellously regular ligamentous apparatus; but the important point is to obtain a satisfactory physiological type. Only great patience is capable of producing this result with certainty. Speaking generally—I might almost say, speaking literally—mechanical therapy ought to be proscribed: it has often led to disaster, from not taking sufficient account of resistance and of pain; it is too brutal, however gentle it may be, and tries to go too fast. Many resections of the elbow have ended in ankylosis because it has been imagined that a new joint could be produced by a mechanical machine.

8. Later Appliances.—Some patients after recovery from arthrotomy or resection derive advantage from wearing a simple supporting apparatus for some months: for the elbow or the wrist a bracelet or gauntlet of leather, for the knee a laced splint, for the foot a boot with lateral supports. After resection of the knee a leather splint with rigid supports should

be advised during the first year or two. After resection of the hip a raised boot is necessary, an orthopædic apparatus useless.

9. Evacuation of Patients with Wounds of Joints.—As far as can be, wounds of the joints should be treated on the spot, moved as little as possible and evacuated as late as can be managed. In a war of position every joint wound, however small, ought to be operated upon immediately after the patient has been brought in, for it is only in this way that a small wound can be made to remain harmless. The patient's evacuation after operation should be carried out after complete immobilisation has been effected : the apparatus to be preferred is a plaster trough. But evacuation ought not to be ordered, save for military necessity, except for convalescents, that is for patients who have been free from fever for many days, who have no pain, and whose wounds are clinically aseptic.

CHAPTER II

WOUNDS AND FRACTURES OF THE SHOULDER

I. Anatomical Types and Clinical Course

It is sometimes very difficult to be sure that the joint is involved when a missile has traversed the shoulder: the thick muscular covering in powerful men, the diffuse pain, the swelling due to effusion of blood which often is extreme, the frequent coincidence of injury to the lung, especially in soldiers hit in the left shoulder, are factors that may render the diagnosis anything but easy when the bony injury is not extensive. It is well to be forewarned of this, for mistakes are common.

It should be borne in mind that if a radiograph is not obtainable it is better to diagnose a fracture that does not exist, than to overlook a joint injury which will manifest itself all of a sudden by grave complications. I lay special stress upon this point, for I have twice received in my ambulance at the front men hit in the lung for immediate incision of the pleura in whom the septic conditions were really entirely due to an arthritis of the shoulder. Immediate exploratory incision showed that the bullet before entering the thorax had ground fragments of clothing into the head of the humerus, and that this was the cause of the infection.

Four prominent anatomical types are observed in injuries of the shoulder.

The crush-fracture (*fracture parcellaire*).—This is a

crushing of the trabeculae of the cancellous tissue after fracture of the cartilage, or the compact shell of the head, with or without a shrapnel ball, splinter of shell or grenade *in situ*.

A fracture limited to the head.—A furrow or groove at the level of the anatomical neck, or a tunnel through the cancellous tissue, with or without radiating fissures, but without detachment of the head. This is more often the result of long-range bullets, and in these cases complications do not usually develop.

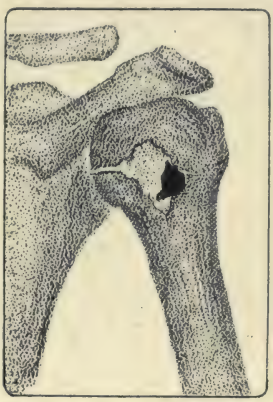

FIG. 10.—The projectile is embedded in the head of the humerus surrounded by a progressive osteitis. The radiograph was taken fifteen days after the injury. Subsequent removal with localised subcartilaginous clearing out of the head of the bone has produced a good result, but the movements of the joint are limited by adhesions. An operation immediately after the injury would have given a better restoration of function.

Complete separation of the head along a line which may correspond to the line of the epiphysial cartilage, which is still present in young soldiers, since it rarely disappears before twenty-two years of age.

Complete destruction of the upper end of the humerus, a very frequent injury, indeed the most frequent of all, produced either by a short-range bullet or by a splinter of shell or grenade. In these cases it is not unusual to find the whole of the upper end of the bone smashed to atoms. The bone-dust and splinters are driven into the muscles which are crushed, lacerated, and contused, and in a few hours become the seat of formidable septic phenomena which develop with great rapidity. These injuries may exist alone or in

conjunction with other fractures of adjacent parts, such as fracture of the coraco-acromial arch, of the glenoid cavity, and of the scapula.

What is the course of these different types?

The crush-fractures, with the projectile remaining in the head of the bone, are sometimes mild in their course when they are due to a bullet or a shrapnel ball, but one often sees progressive osteitis occur around the projectile, or œdema of the shoulder signifying deep infection, and sometimes a late suppurative arthritis. Complications are the rule if the injury is due to a shell-splinter.

The crush-fractures and the fractures limited to the head may run an aseptic course and behave like simple fractures when they are produced by long-range bullets which have perforated the shoulder like a trocar, through punctiform skin openings.

But in all the other cases and invariably when the wounds are made by splinters of shell or grenade, however small the wound of entry may be, osteo-articular infection is the rule; one should always be on the look-out for it because of its great frequency. The few cases which progress without grave symptoms are very similar at first to those which are followed by gas gangrene.

Often, especially when there is destruction of the head of the bone by a bullet or shell-splinter, infection follows with extreme rapidity; in a few hours the temperature reaches 40° C. (104° F.); the general condition becomes grave, the complexion waxy, the lips pale and the cheeks flushed; the shoulder is swollen and globular; the signs are those of an acute diffuse cellulitis; the least movement makes the patient cry out. The same evening or on the next day there is gas in the tissues, the appearance of the patient is that of a man profoundly toxic, and, unless active intervention is practised, death quickly ensues.

This is the usual course of about a third of the cases

at the front unless immediate action is taken. More frequently the symptoms are less acute, the infection is slower; the shoulder slowly swells up, the flat surfaces are effaced, hollows disappear, the whole region is painful, and from the swollen lips of the wounds there exudes a fœtid sero-purulent discharge. Sinuses occur on all sides, but especially in front along the biceps, and in the axilla. Unless appropriate treatment of the bony lesion is carried out, the patient wastes, becomes cachectic, and slowly dies of amyloid degeneration, if disarticulation is not performed. A small number of cases get well spontaneously with ankylosis and sinuses.

Results such as these of fractures of the shoulder left to themselves, can be avoided; they ought no longer to be seen. A wound of the shoulder correctly treated from the start ought not to suppurate, and should get well quickly.

II. Primary Therapeutic Indications

1. Simple Immobilisation.—This is only suited to very mild cases, that is to say to bullet wounds with punctiform openings. These wounds do not suppurate and the cases behave like simple fractures. The only indication in them is to apply an aseptic dressing and strictly immobilise the joint in a plaster casing made in the manner described farther on. If the cases are numerous, one would apply a wire splint suspended from the top by means of a sling over the opposite shoulder. Immobilisation should be kept up for three weeks, so that the hæmatoma can be absorbed without injudicious interference, after which some cautious attempts at movement should be made, and the arm placed in a sling. Generally, consolidation is rapid, but ankylosis is the rule. If radiography shows much damage to the bone, it will be well to apply continuous

extension and treat the injury as if it were a fracture of the shaft.

2. Esquillectomy and Sub-periosteal Resection.—A limited bone operation is necessary in all cases of medium severity, that is to say in the more or less extensive fractures of the head of the humerus; esquillectomy is suitable for the smallest injuries, resection for the others, which form the majority.

Let us take an apparently simple case. A small shell-splinter has traversed the shoulder from before backwards and a fracture is manifest; as yet there is clinically no infection, and the wound is only of a few hours' duration. One is tempted to say, "No intervention, simple immobilisation: if symptoms of infection appear, there will always be time to make an incision." This easy-going optimism appears all the more justified because at the shoulder a flail joint, due to loss of bone is very crippling, especially if the muscles are destroyed: ankylosis is better than a flail-arm, and one can understand the desire to wait until one is forced to intervene. No one has the right to do this: the risks of waiting are too great to allow one to expose the patient to them by speculating upon the chances of a natural cure. The uncertainty of delay, the impossibility of knowing whether urgent evacuation will become necessary, the ever-present menace of infective complications whose severity it is beyond one's power to foresee, our absolute ignorance of what the missile has implanted in its passage through the bone or the joint, taken together, impose upon us the duty of making an early intervention in all cases except the punctiform bullet wound, in order to expose the damaged bone and clean it.

The advantages of this method of procedure are the following:

Complete suppression of severe primary septic phenomena (gas gangrene, septicæmia, acute articular osteitis), which carry off a large number of patients.

By practising primary clearing of the bone lesion by esquillectomy or resection, I have not lost a single case of injury to the shoulder.

Avoidance of early secondary disarticulations, which are numerous in the ambulances when the wounded arrive late, or in which immediate systematic operation is not the rule. Two-thirds of these could have been avoided by primary resection. Personally, I have only done one disarticulation of the shoulder in twenty months of war.

Progress that is entirely or almost entirely aseptic from the clinical point of view, without suppuration of the articular lesion, with rapid cure and preservation of the functions of the muscles.

If the operation is correctly done, that is to say rigidly sub-periosteally, if the muscles are sound, if the circumflex is not severed, and if the bony damage is not too extensive, the prognosis as to function is ordinarily good, often excellent, rarely bad. On the other hand, many patients who get well with ankylosis suffer from some degree of osteitis, have sinuses, and are exposed to recurrent attacks of infection. I have lately seen a soldier wounded by a bullet fourteen months ago who recovered with incomplete ankylosis after repeated drainages, and who got a chill and was suddenly seized with a very acute attack of epiphysial osteomyelitis with extensive suppuration on the eve of setting out for a colony where his business interests lay. Systematic abstention from early operative interference entails terrible future risks. That is why we should bear in mind the possible future of our patients, and endeavour to minimise the risk of suppuration in any joint.

What practical steps should be taken?

As soon as possible the wound should be explored, the wounds of entry and exit laid open, torn muscular débris clipped away, and particles of clothing and foreign bodies sought for. When this has been done,

the joint is freely exposed and the seat of fracture methodically examined by enlarging the opening made by the projectile.

(*a*) If the fracture is incomplete and the missile is embedded in the bone, the damaged area of bone should be cleared out with a curette and anything removed that appears suspicious. These sub-cartilaginous operations give excellent results. After

FIG. 11.—Simple fracture of the head of the humerus by shell-splinter. Separation of the head of the bone was treated by early resection by the classical incisions, in spite of the wound of entry being posterior.

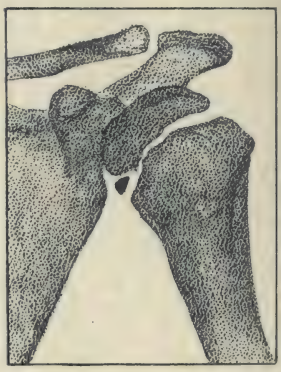

FIG. 12.—Result at the end of two months, when the wound had completely healed without suppuration. The patient has recovered full movement of the joint.

the missile has been removed, nothing further is required than to plug the wound loosely with aseptic gauze.

(*b*) If the fracture is very small and only involves part of the head of the humerus, simple esquillectomy will suffice ; any loose cartilage is removed and the wound is plugged lightly and left open. It goes without saying that all foreign bodies and débris of clothing on the surface of the bone are carefully sought for,

and that any projecting points are chiselled away; no attention need be paid to vertical fissures, which will remain aseptic if the principal area of damage is cleared out. The same line of treatment will be pursued if the head of the bone has been split vertically; the part continuous with the shaft will be left after trimming it up with cutting forceps so as to adapt it to the glenoid cavity.

(*c*) If the injury is more extensive and there is a complete fracture with numerous fragments, and fissures extending into the shaft, it will be necessary to leave the orifice of entrance made by the projectile after cleaning it thoroughly, and to open the joint by the classical incision for resection along the inner border of the deltoid, incise the capsulo-periosteal sheath outside the bicipital groove, and separate the periosteum with the rugine in the direction of the bony injury. If the head is free in the cavity of the joint, it should be removed and the joint cavity cleared of all fragments; if the head of the bone is comminuted, the humerus should be sawn through at the level of the anatomical neck and the fracture a little obliquely downwards, and this will be a very good section if the insertion of the capsule has been carefully preserved. After this has been done, a posterior counter-opening for drainage is made, enlarging the wound made by the projectile if it is conveniently situated, or making a fresh opening in a suitable spot when there is no posterior wound, as will be described later on.

3. Extensive Resection.—At the shoulder the explosive effects of a short-range bullet, or fragment of shell or grenade, are often very marked, and the whole of the upper end of the humerus may be smashed up. The muscular damage is considerable, and the injury to the bone affects both head and shaft, the upper third of the humerus being destroyed and reduced to splinters which are driven into the muscles.

The least delay in operating allows the rapid development of infection.

A good number of these injuries have been successfully treated by disarticulation at the shoulder-joint. On one day in a neighbouring ambulance I saw six disarticulations which had all been performed during the same week for fractures of this kind. Yet whenever the vessels and nerves of the arm are intact one may try to save both life and limb, even to the extent of actually removing the entire upper half of the humerus. This procedure is at present in rather bad odour, because in the early days of the war many inexperienced surgeons performed esquillectomies that were too extensive and perfectly useless, and through ignorance caused terrible mutilations. But the cases under discussion do not come into this category. In them we have to choose between an extensive removal of bone in order to preserve the hand and its movements, and disarticulation at the shoulder: the former operation is, then, one that cannot be too highly recommended. Indeed the opening up of this enormous damaged area stops infective complications, especially if it is immediately followed up by regular sunlight baths; after a longer or shorter period of very localised suppuration, which the sunlight shortens remarkably, repair occurs rapidly and uneventfully, and the patient, if care is taken of his muscles, recovers with a useful flail-arm, a normal hand, and very mobile fingers which are certainly more useful than even the best artificial limb after disarticulation. Doubt has been cast upon the usefulness of this "deossified" limb. But it is none the less certain. In peace-time one was able to study the functional value of cases of total removal of the humerus; the results were so satisfactory that during recent years extensive or total removal of the humerus was advised for neoplasms. "Deossification," therefore, is quite legitimate in military surgery for the very severe cases which are met with there. I per-

sonally have practised it many times, and I was able to show the Société de Chirurgie a patient who had lost more than six inches of the humerus, and further had had a resection of the upper ends of the bones of the forearm done on the same side, and yet enjoyed considerable useful movement. The operation should be done as far as possible with the rugine, with as little periosteal damage as can be managed. One can hardly expect from these measures a bony column sufficiently firm to unite the part which remains with the glenoid cavity, but the muscles are more completely preserved, and their contraction will eventually greatly improve the future condition of the wounded whom we are all so anxious to save.

It is the rule that in cases of fracture where disarticulation appears necessary, but where integrity of the vessels and nerves leads one to hope for a useful hand, the surgeon should do a primary resection without being deterred by the fear of too extensive sacrifice of bone. This method always succeeds in preventing or minimising septic complications.

To sum up, we may say that, putting aside gunshot wounds with punctiform skin openings, one should practise the following primary operations for all wounds of the shoulder:

For crush fractures, removal of fragments and curettage.

For limited fractures, sub-periosteal resection.

For destruction of the upper end of the bone, very extensive resection.

This method will avoid septic complications and disarticulation. But there are certain complicated cases, such as multiple fractures of the shoulder girdle or co-existing wound of the chest, which demand special treatment.

(*a*) *If a fracture of the humerus is complicated by multiple fractures in its vicinity*, such as fracture of the coraco-acromial arch, of the glenoid cavity, and

especially of the scapula (a frequent occurrence), very careful clearing out with sub-periosteal removal of the fragments is more necessary than ever. In cases of this kind I have seen disarticulation performed at the shoulder-joint followed by partial resection of the scapula. It is an over-rated method: esquillectomy is quite sufficient if it is properly performed.

(*b*) *If there are concomitant pulmonary injuries*, which is frequent, the case is difficult: on the one hand the condition of the lungs, the dyspnœa, and the shock contra-indicate even a short anæsthesia, while on the other hand there is the imminent risk of formidable complications.

It is, however, possible to surmount the difficulty: the dyspnœic patient should have some morphine at once and be put to bed wearing a sling which fixes the fractured limb against the thorax. After the lapse of some hours, when the dyspnœa is less and the patient is better, the sling is removed, and after another injection of morphine the scapular wound is laid open freely with scissors, and when thus exposed to the air it is no longer exposed to primary gas gangrene or fulminating sepsis. Without interfering with the deeper structures, the arm is again fastened to the thorax. In this way one can safely wait without causing aggravation of the pulmonary condition. As soon after this as the state of the chest will permit, further surgical intervention will be necessary. These patients bear an anæsthetic fairly well, especially if it is preceded by an injection of morphine.

III. Operative Technique

1. Means of Access to the Articulation.—Every operation on the shoulder must be dominated by the desire to preserve the attachments and the nerve-supply of the deltoid. Its nerve, the circumflex, emerges from the axilla between the humerus and the

outer edge of the long head of the triceps, runs round the surgical neck which it embraces like a collar in company with the posterior circumflex artery, and approaches the joint as it runs towards the front of the shoulder. On its way it gives off branches which pass vertically into the deltoid muscle, and terminate at its anterior border. The nerve thus runs more or less parallel with the outer border of the acromion, from which it is distant, in an adult of medium height, about 2¼ inches No posterior incisions, therefore, should be made at this level lest they should divide the nerve and thus paralyse the greater part of the muscle. The area of election for an incision is the front of the shoulder, just outside the interval between the deltoid and the pectoralis major, which interval is itself to be avoided because of the cephalic vein.

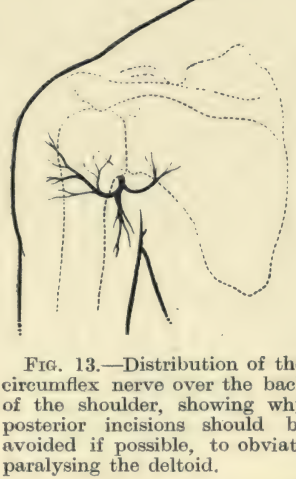

FIG. 13.—Distribution of the circumflex nerve over the back of the shoulder, showing why posterior incisions should be avoided if possible, to obviate paralysing the deltoid.

In a general way any wound of entry or exit of a missile lying outside the area mentioned above should be looked upon as not available as a route to get access to the head of the bone, but rather as an opening that can be made use of for drainage.

These general principles being laid down, the procedure should be as follows:

(*a*) When there is no posterior wound, an exploratory incision is made at the level of the wound of entry; it should not extend below the limits indicated above. If there is not enough room, it should be extended upwards

to the posterior border of the acromion, from which the insertion of the deltoid should be separated with a rugine for about half an inch or so.

If, after incising the deep fascia and exposing the joint, a limited injury is found that can be dealt with by a superficial esquillectomy and extraction of the missile, this exploratory incision will suffice. If, on the contrary, the bony lesions are extensive, and if there is a comminuted fracture of the head necessitating resection, the classical anterior incision must be made, the posterior opening serving simply as a means of securing the necessary drainage.

FIG. 14.—The best incision for exposure of the shoulder-joint.

(*b*) When there is an irregular wound with smashing up of the head, and in all cases in which resection appears necessary, an anterior incision should be made at once without troubling about the wound of entry.

This incision, beginning half an inch below the clavicle, runs downwards and outwards in the direction of the fibres of the deltoid as far as may be necessary. If there is not enough room above, the insertion of the deltoid into the clavicle can be removed for about an inch. The edges of the incision in the muscle are drawn apart and the articulation is exposed. Even when the capsule is torn, although there may be severe damage to it, it is important to make the incision to the outer side of the tendon of the biceps and parallel to it. This structure can be defined accurately by rotating the humerus a few times.

2. Subcapsulo-periosteal Denudation: Section of the Bone.—From this point onwards the cutting rugine alone ought to be used. If the fragments of the head are too freely movable, they should be fixed with forceps, so that the periosteum can be stripped off, biting into the bony tissue rather than leaving any of the fibrous attachments adherent to it. In this way the insertions of the supra-spinous and teres minor muscles on the outside will be carefully detached, the humerus meanwhile being internally rotated; on the inside the insertion of the subscapularis is similarly treated, the humerus being rotated externally. It is important to strip off the periosteum everywhere, and to tear nothing, so as to preserve as far as possible the capsular periosteum as well as the insertions of the muscles.

If the missile has struck the upper part of the head of the humerus, splintering the intra-articular portion, it is enough to clear the joint cavity of all bony fragments and smooth off any projecting points with a chisel, so as to shape the extremity of the humerus to the glenoid cavity.

If the head of the humerus has been split vertically, the part that remains attached to the shaft is preserved, and its surface is trimmed with bone forceps, which should be made to remove the articular cartilage as well.

If the end of the bone has been extensively comminuted, the whole of the head is removed, leaving only any large fragment of the tuberosity that may be present. If necessary, the saw is applied through the surgical neck. No notice need be taken of fissures running down into the shaft. They repair of themselves when the principal injury has been suitably treated.

If the upper extremity of the humerus has been entirely destroyed, it must not be thought that the injury to the bone is too great to admit of cure, and

that disarticulation must be performed. The anterior incision should be enlarged as much as may be needful and the fragments of the head and shaft carefully removed by means of the rugine and followed down as far as necessary. Any very large fragments, embracing one-fourth the circumference of the shaft, should be spared. But in these cases there must not be undue economy of bone in order to save the limb. By removing from five to six inches of humerus, I have succeeded in avoiding disarticulation, even where there were other accompanying fractures, of the inferior maxilla in one case, of the radius, the ulna, and of the skull in another.

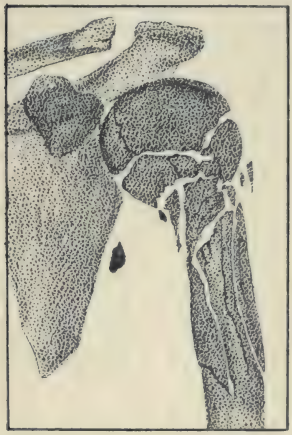

FIG. 15.—Comminuted fracture of the head of the humerus caused by a shell-splinter with extensive destruction of muscular tissue. Removal by the rugine of the head of the bone and many fragments obviated disarticulation and has preserved a useful upper limb. A cure was obtained in two and a half months without any sinus.

If the fracture of the humerus is complicated by fracture of the body of the scapula, the method will be the same, and it should not be thought that the injuries are too extensive to admit of conservative treatment. The coraco-acromial fractures should be cleared in the same way as the humerus, but less freely. When the articular cavity is cleared, these injuries run a favourable course ; if the glenoid cavity is broken, complete scapulo-humeral resection should be done by means of a deltoid flap, turning the muscle off its attachment to the acromion.

When there is a fracture of the body of the shoulder-

blade, the scapular wound should be incised and the fracture treated by an extensive esquillectomy. Unless this is done, severe septic infection may take place in the subscapular fossa and endanger life.

Likewise if the glenoid cavity is broken, free esquillectomy should be performed : sufficient articular support will be obtained if the periosteum is preserved.

Whatever may be the extent of the intervention, every resection of the shoulder and every intra-articular esquillectomy of any importance should be completed by a posterior counter-opening for drainage at the seat of election, that is above the circumflex, utilising if possible one of the wounds made by the missile.

IV. Post-Operative Treatment

1. Temporary Dressing and Immobilisation.— When posterior drainage has been established, the anterior resection or esquillectomy wound is plugged with aseptic gauze. While an assistant supports the elbow, and holds it slightly away from the body, an absorbent dressing, thicker behind than in front, is applied. Before this is done, care is taken to fix the drainage tube with a pin, and to cut it off very short, so that the pressure of the dressing cannot make the contact unbearable.

Immobilisation can be done in two ways.

(*a*) If the patient remains on the spot and can be followed, especially when the operation on the bone has been important, and when an abundant discharge from the wound is expected, it is only necessary to keep the arm against the side by means of the dressing, the elbow being bent and the hand brought up across the chest. After the limb has been surrounded with wool, it is fastened to the chest by a circular bandage which supports the elbow by means of turns of bandage passing over the sound shoulder. This bandage,

which is similar to that for dislocation of the shoulder, secures perfect immobility when it is well applied, and the patients on whom it is used do not complain. I use it habitually in the early stages of treatment.

(*b*) When it is seen that the dressing will be able to remain in position for several days, and the wound

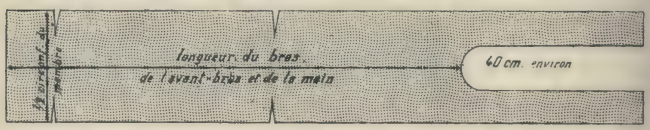

FIG. 16.—Pattern of casing for immobilising the upper limb and particularly the shoulder.

will progress aseptically, or still more, if the patient is liable to unexpected evacuation, a plaster casing should be made in the following manner: The splint is made of a dozen thicknesses of tarlatan the length of the limb—measured from the prominence of the shoulder to the thumb with the elbow flexed—increased by about 16 inches). This is cut so as to obtain:

(1) A covering for the postero-external surfaces of the arm and forearm and the ulnar side of the hand, embracing more than half of the circumference of the arm above, and just half the circumference of the forearm below.

(2) Two bands to pass obliquely across the thorax.

The upper part of the splint will form a shoulder-cap, closely embracing the prominence of the shoulder. To make sure of a perfect fit, the two thoracic bands are crossed over each other before carrying them across to the opposite axilla, so that their overlapping may strengthen the zone of flexion. At the level of the elbow two notches are cut to permit of flexion (fig. 16). For the evacuation of elbow wounds a plaster casing identical with that shown in fig. 41 may be made.

This casing is fixed by means of bandages which go

round the thorax above. If care is taken to put wool in the axilla to keep the humerus in good position, *i.e.* to prevent the tendency to adduction produced by the pectoralis major, this casing will last for many dressings : it is removed at each dressing, and re-applied if the discharges have not robbed it of its firmness.

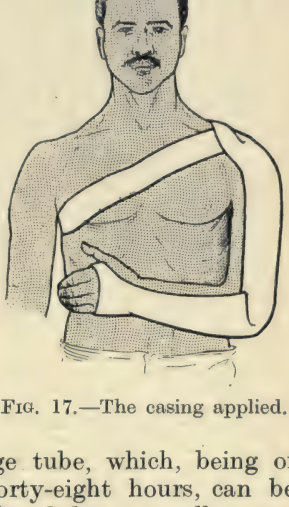

FIG. 17.—The casing applied.

2. LATER DRESSINGS AND PERMANENT IMMOBILISATION. — There is every reason to delay the dressing as late as possible : it is well not to change it for three or four days, even if it is very soiled, or longer if possible. Sometimes severe pain makes it necessary to inspect the wound earlier. This pain is often due to the posterior drainage tube, which, being of use only during the first forty-eight hours, can be withdrawn for good or replaced by a smaller one. As soon as the wound is healing well, the dressings can be facilitated by using a plaster apparatus provided with a window or a metal interruption. The extent of the wound ought to decide the choice between these patterns, which are made in the following manner :

(*a*) If the wound is not too extensive and there is little discharge, and if its edges are supple, a " windowed " splint will be made.

To do this, the thorax is covered with a jersey, or a roll of gauze, and a jacket is made by means of plaster bandages. It is not necessary to incorporate any splinting. Two or three bandages 5½ yards long will suffice to cover the thorax with a firm plaster

shield, moulded over the shoulder and both clavicles. When the thickness is considered sufficient, the bandage is carried in figures-of-eight from the shoulder over the upper limb round the axilla, and then down over the arm and forearm as far as the metacarpus. The arm is fixed in a position of abduction, the elbow slightly away from the body, and the forearm flexed midway between pronation and supination, the thumb upward. The upper limb being completely covered in regular turns with three bandages, windows to display the wounds are cut out with a knife, whilst the plaster is drying. The openings should be large enough to prevent the plaster from being soiled, and some dressing should be slipped under their edges to avoid friction ; the casing is also cut away beneath the axilla. This splint should be worn for a month, at the end of which time cicatrisation will generally be complete. A sling may then be substituted and movements commenced.

FIG. 18.—Casing with window.

(*b*) If the wound is very extensive and large openings are called for, a bracketed apparatus should be employed. This will be constructed in accordance with the general rules of immobilisation, that is to say, it will take in the trunk and the elbow. In order that the arm may be well supported, a metal triangle made out of a piece of bent hoop-iron, or some similar

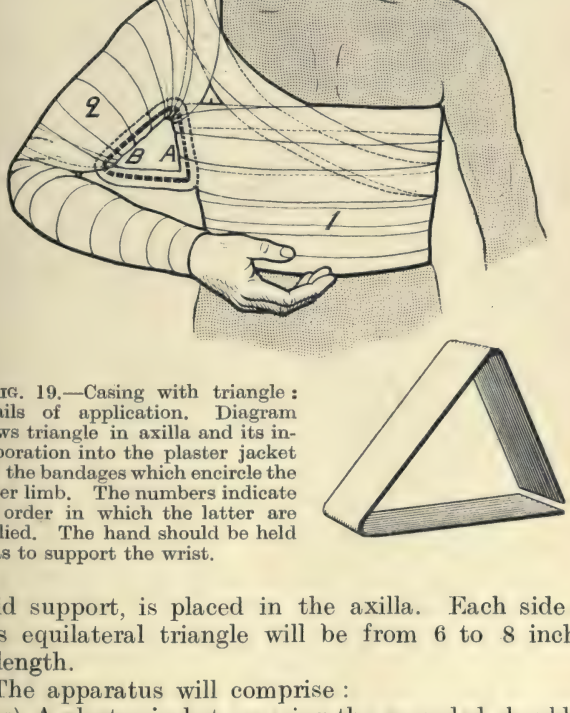

FIG. 19.—Casing with triangle: details of application. Diagram shows triangle in axilla and its incorporation into the plaster jacket and the bandages which encircle the upper limb. The numbers indicate the order in which the latter are applied. The hand should be held so as to support the wrist.

rigid support, is placed in the axilla. Each side of this equilateral triangle will be from 6 to 8 inches in length.

The apparatus will comprise:

(*a*) A plaster jacket covering the wounded shoulder, made with three or four bandages $5\frac{1}{2}$ yards long.

(*b*) A bandage going round the upper limb from the shoulder to the lower border of the metacarpus (three bandages).

(*c*) A triangle made of hoop iron, padded with wool surrounded by a gauze bandage.

(*d*) An interruption of iron wire shaped like a bridge ; the arms of this bracket, whose extremities will be raised a little to prevent it from slipping, take purchase

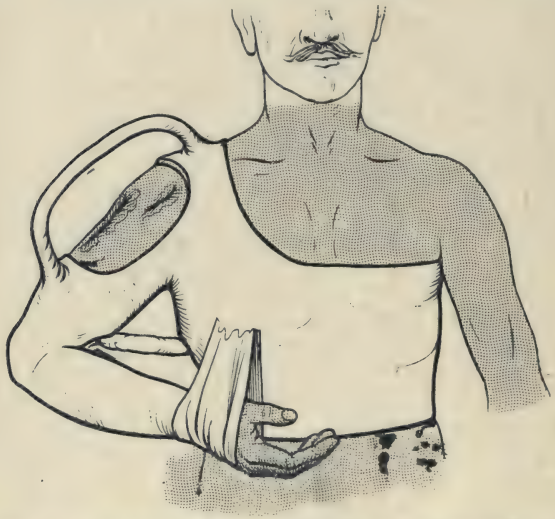

FIG. 20.—The same casing completed ; a bandage supports the forearm and hand.

above from the cervical side of the coraco-acromial arch, in a line from the shoulder to the nape of the neck ; and below, from the lower part of the arm below the wounds.

The plaster will commence with the corset, in which will be incorporated the thoracic side of the axillary triangle. When that has been well fixed, the bandage will pass over the shoulder in a figure-of-eight round

the axilla and the neck ; then it is carried down the arm, fixing the humeral side of the metal triangle. Then follows envelopment of the elbow and the hand in the position already indicated.

Lastly, the metal interrupting bracket will be placed in position and fixed to the plaster casing by another bandage. All that remains to be done is to cut the plaster bandage away from the area of the wounds and smooth off the edges of the apparatus.

3. MOBILISATION.—This ought not to be commenced

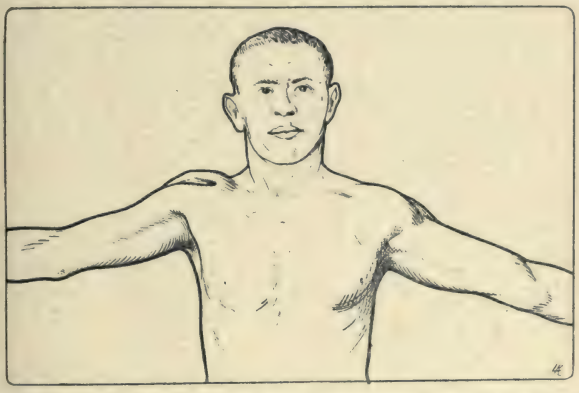

FIG. 21.—Result of primary resection for comminuted fracture of the head of the humerus, after six months. The scar of the anterior incision is distinctly seen on the right shoulder. The arm of the side operated on appears to be raised higher than the other, but by examining the line of the shoulder it is easy to realise that the shoulder-blade takes part in the movement.

too early. It is necessary indeed to wait until the humerus is sufficiently fixed against the glenoid cavity, before seeking to get even slight movement. Unless this precaution is observed, the humeral extremity may be dislocated by the adductor muscles below and in front of the coracoid process, and the result will be deplorable.

If resection has been limited to the head, no move-

ments should be commenced for a month. In case of more considerable loss of bone, a longer period is required ; but as soon as cicatrisation is advanced a little the muscles should be either massaged or electrified. Exposure to the sun is one of the best agents for the preservation of muscles. Before any attempt is made at passive movement, voluntary contraction of the muscles should be promoted with the limb still fixed. Elevation and rotation should be the first movements attended to. Abduction, which is the most useful movement, is the most difficult to obtain. That is due principally to injury to the deltoid. Out of ten patients, I have only obtained it satisfactorily in two.

As a general rule, and contrary to what happens in the elbow, undue laxity of the joint is to be feared, rather than ankylosis.

V. Evacuation of Patients with Shoulder Wounds

With the exception of mere tracks with punctiform openings, all wounds of the shoulder ought to be explored as soon as possible. None ought to be considered as primarily mild.

Removal to the base, without a clearing operation, ought not to be practised unless there is considerable over-crowding, when it becomes clear that the patient will be more quickly operated upon if he is moved than if he remains *in situ*. In this case the patient ought always to be detained in the first surgical line (*relai*) he comes to. He should never travel for more than twenty-four hours.

What is the most favourable time for evacuation of a patient who has undergone esquillectomy or resection? It is at the end of a week, if the patient cannot be kept longer. Simple esquillectomies can travel after three or four days, with their injured limb immobilised in a plaster casing designed for that purpose. After

extensive operations for the removal of bone, as for destruction of the upper half of the humerus, it is advantageous to retain the patient as long as possible, fifteen days at least.

Apparatus for transport.—The plaster splint described above (see fig. 18) is generally sufficient. A plaster casing of the Hennequin type may also be used. The elbow should be slightly adducted without being in contact with the wall of the thorax, the forearm flexed, and the axillary pad in place. This apparatus should be removed on his arrival. The journey should not exceed forty-eight hours.

VI. Treatment of Patients seen late or after Evacuation

1. A PATIENT, WHO HAS BEEN LYING OUT FOR SOME TIME, ARRIVES AT THE AMBULANCE AT THE END OF 24 TO 36 HOURS.—There are all the signs of a commencing suppurative arthritis, or of a diffuse phlegmonous inflammation of the shoulder, often gaseous. The wound is sloughing and looks foul.

The sloughing edges should be immediately excised. Sub-periosteal removal of all the fragments that are free and those that are adherent and likely to interfere with drainage should be done at once through an anterior incision. It is really an extensive resection, atypical, like the bone section, having for its object the free exposure of the seat of the articular fracture. If the fracture is incomplete, immediate resection of the head of the humerus should be done.

If the humerus is smashed up and septic, subperiosteal removal of the bone, described above, will be the operation of choice and will generally check the infection ; if it persists, however, especially in a case of comminuted fracture, or if at the outset the gravity of the general condition makes one doubtful, disarticulation at the shoulder-joint should be done without hesitation.

2. A PATIENT CORRECTLY OPERATED UPON AT THE FRONT ARRIVES AT THE BASE IN GOOD CONDITION.—(*a*) A patient who has had early arthrotomy with removal of all foreign bodies for parietal fracture, gets well rapidly. In three weeks fixation should be abandoned, and gentle movement commenced. Treatment by mechanical movement is expressly contra-indicated. As soon as active movements can be performed, the patient himself will do all his own movement.

(*b*) In the case of a patient who has undergone arthrotomy for a splintered fracture, and is doing well, it is necessary to promote ankylosis by strict immobility. The limb is very slightly abducted, the elbow just away from the body, and no heed should be taken of loss of movement, which is inevitable.

(*c*) A patient who has had resection performed ought to be treated according to the indications given above.

3. A WOUNDED MAN ARRIVES WITHOUT HAVING BEEN OPERATED UPON, AND WITHOUT ANY SYMPTOMS OF SERIOUS INFECTION.—Suppose a patient arrives on the third day ; one confines one's energies to enforcing strict immobility by means of a plaster splint, made as described above. Some days later, aided by radiographs, a search can be made for missiles, if there be any, or dead fragments of bone. These cases get well, but often with ankylosis and sinuses.

4. THE OPERATIVE TREATMENT HAS BEEN CARRIED OUT LATE, OR EARLY TREATMENT HAS BEEN INSUFFICIENT.—The patient arrives in a septic condition with free suppuration.

(*a*) An arthrotomy and esquillectomy have been performed, but the radiograph shows missiles left behind or fragments of bone in a fair way to necrosis. After forty-eight hours of observation and rest, whatever the date of the injury, it will be necessary to complete the first operation and to remove missiles and fragments, carefully sparing all periosteal remains, and excising dead tissues, generally fragments of an

aponeurosis or tendons. Even should the short head of the biceps be concerned, it should be cut away, for a tendon does not recover, and takes a long time to come away spontaneously. If the bony lesions are extensive, resection of the head of the humerus, which is the operation of choice, will be done without hesitation.

(*b*) The injury to the bone has not been touched. There is suppurative arthritis starting from a septic centre in the bone ; the best treatment is resection of the humeral head. Arthrotomies do not drain so well, nor do they allow the cause to be reached. On the other hand, late resections, if they are not too late, often give very good results ; the recovery of function is often better than with primary resections : if one were sure of being always just in time, the general indication would be to wait. At least that is the accepted opinion. But it rests on no precise reason : periosteal regrowth occurs quite as well in a primary as in a secondary resection. In short, the function of the new joint depends above all on two factors : the conditions of the muscles, and the extent of the bony loss. Whatever may come of the argument, one will resect with hope of a good functional result.

If there are purulent sinuses round the joint, notably behind and internally, resection, combined with counter-openings and complete cleaning out of dead fragments, will almost always enable one to avoid disarticulation. That will, however, sometimes be necessary in consequence of the gravity of the general condition, especially if scapular injuries co-exist.

5. THE PATIENT ARRIVES WITH HIS WOUNDS ALMOST HEALED.—(*a*) A sinus persists. Generally this is at the antero-internal part, quite near the axilla—at least I have always seen it there. After radiography the dead bony fragment, or the missile which keeps up the sinus, is sought for, even by doing a sub-cartilaginous scraping out of the spongy tissue of the

head of the bone. This curettage generally ensures a complete recovery, but the wound must be kept freely open, and no attempt must be made to obliterate the cavity by an antiseptic paste, which would certainly be extruded. Sunlight benefits these old bone cases marvellously.

(*b*) The limb is flail-like from want of bony growth. One must distinguish between two types of this condition : limbs which are active though flail-like, and those which are absolutely useless. In those which retain some activity, the muscles are still in a good condition, a correctly performed operation has made the best of them, has saved their nerve supply and maintained their attachment to the periosteal sheath. They preserve their power of contraction, are able to raise the lower end of the humerus with some strength, and thus permit useful movements. In these cases one is tempted to think of bone-grafting. At the present time the operation seems inadvisable and not likely to succeed ; the graft would be liable to be displaced, if not absorbed. In a case of this kind in a patient, two-thirds of whose humerus I had resected as well as the ends of the two bones of the forearm at the elbow, a supporting case fitting on to the shoulder has permitted him to use the limb.

In those arms which are flail-like and quite useless, where there are no longer any muscles, suspension must be resorted to by means of an apparatus encircling the trunk and shoulder, with a firm casing enclosing the arm, and giving a solid point of support for the movements of the elbow and the hand. (See fig. 97.)

CHAPTER III

WOUNDS AND FRACTURES OF THE ELBOW

I. Anatomical Types and Clinical Course

EVERY wound in the region of the elbow, even if it extends to the bone, is not necessarily a wound of the joint. Projectiles often chip the surface of one of the bones, without, strictly speaking, penetrating the joint. These wounds, which may be called parietal or para-articular, generally run a very simple course after a suitable incision has been made for the removal of the foreign body and any dead organic débris. Scarcely any limitation of the movements of the elbow is left when they heal. I have seen a dozen cases like this, but it is not necessary to take them into account in speaking of wounds of the joint, and they will not be considered further here.

One only really considers as fractures of the elbow injuries to one at least of the three bone ends inside the synovial membrane.

Theoretically the elbow can be traversed through and through without the bone being damaged, but in practice this very rarely happens. As a general rule, every clean perforating bullet wound of the elbow, however simple it may appear and whatever be its direction, is accompanied by injury to both bone and cartilage, even when radiography shows nothing; when it does show anything, there is always more damage than is apparent.

One bone only may be struck, but that is excep-

tional; out of thirty-six cases, verified by operation, I have only observed this three times. More often, the fracture implicates two bones; when the principal injuries are those of the radius or the ulna, there will be extensive damage to the corresponding or opposite part of the humerus, and vice versa. Similarly, the two upper articular ends of the bones of the forearm may be broken simultaneously. Besides, it is easy to understand that all possible combinations may occur, according to the varying path of the missile and the different positions of the arm and forearm. It only matters to remember that *there is always more damage than appears from the symptoms*, and that the fractures of the epiphyses are often prolonged by fissures far down the shaft.

FIG. 22.—Fracture of the elbow by bullet with punctiform skin wounds. Aseptic course in spite of extensive bony injuries. Recovery by simple immobilisation for one and a half months, with limitation of movement; flexion up to 90 degrees, extension normal. Patient seen in consultation to consider the advisability of further resection, which has been rejected as useless.

In these fractures, which sometimes are very little comminuted, as is especially the case in the humerus, the displacement is usually not considerable. I have always seen the olecranon but slightly displaced, and simply bent forwards and drawn up to the level of the cavity which normally receives it. The head

of the radius remains adherent to the tendon of the biceps by its periosteum. The coronoid process is generally drawn forwards. But all these structures are often unrecognisable, being reduced to small splinters which remain either in the region to which they belong, or are scattered somewhere about the torn-up articular cavity. The missile, too, is close by, but in its course it has often caused fragments of clothing to adhere to the bony points, whence the frequency of infection.

Perhaps the most frequent type is complete destruction of the elbow in which two and sometimes all three articular ends are demolished ; there only remains a sort of bony mess in place of the joint, with splinters and osteo-cartilaginous fragments more or less widely scattered about.

What becomes of these different injuries if they are left untreated during the first few days ?

The surgeon at the front has to distinguish three categories :

Bullet wounds with punctiform openings.

Wounds, blind or otherwise, small or of moderate size, made by splinters of shell or grenade.

Large wounds made by short-range bullets, or by large pieces of shell, with great loss of the soft parts and smashing up of the elbow.

(*a*) The fractures caused by bullets with small punctiform skin openings are the mildest ; they usually heal without sepsis, if the limb is suitably immobilised. It must be remembered that, in these cases, it is not the extent of the bony injury but the dimensions of the skin wound which determines the gravity of the case. With a small fracture and a large wound of exit, sepsis is certain. On the other hand, an aseptic course is possible when there is great destruction and the wound is very small. This is not because the infection is introduced from without inwards by the cutaneous wound, but because the

bullet which gives rise to small skin-openings is really one fired from a distance, hitting the body point foremost, and not generally carrying anything with it. It is the famous "humane bullet"; whilst the bullet which produces explosive effects is deformed, has ricochetted or is wobbling, and carries with it débris of clothing and leaves behind it all kinds of infective organisms. The wound it produces has the same elements of gravity as one caused by a shell-splinter, and no distinctions as to the variety of the projectile need be made.

(*b*) In the fractures with skin wounds of small or moderate dimensions apparently of a mild type and caused by splinters of shell or grenade, it is almost necessary to reverse the formula : a small blind wound is more formidable than a large open one. These are generally cases with small skin wounds but much deep-seated damage which is shut off from the air, and is therefore under favourable conditions for the rapid development of septic gangrene. When a wound is wide open, these very acute symptoms are less often observed ; ordinarily an acute arthritis occurs with profuse suppuration and discharge of sloughs and necrosed bone ; the arm becomes enormously swollen ; purulent sinuses call for multiple incisions and repeated removals of bony fragments. After many alarms and several operations, the patient recovers with ankylosis and with or without, more often with, sinuses.

Even if cicatrisation is complete, it does not do to think that everything is well ; in about half the cases there are sequestra in the ankylosed bones, or granulation tissue containing spicules of bone which has all the appearance of tuberculous tissue. It is, however, really only septic, and bacteriological examination shows staphylococci in large numbers. They may disappear gradually, but for a long time this latent infection will be dangerous : it explains the unexpected recurrences of infection, the painful attacks of lymphangitis on the occasion of a chill or of a blow on the

elbow, and in many cases a decided decline in the general health, inexplicable on any other grounds.

Out of twelve resections of the elbow which I have performed for ankylosis after war-wounds, I have found conditions of this kind in seven. In the other five cases the ankylosis had ensued in the ordinary course, and there had been no septic relapses. But in two cases it had only been obtained after many operations that had left the skin adherent to the muscles which were atrophied, fibrous in character, and with much diminished functional power: in consequence of pain, abundant suppuration, and repeated dressings, the position of the limb had been badly overlooked, and after eleven months of painful treatment, a vicious ankylosis necessitated resection for the deformity, which the muscular insufficiency would have almost contra-indicated.

(*c*) In extensive crushing of the elbow by shell-splinters or the explosive effects of bullets, one may see the very rapid development of a septicæmia which ends rapidly in death, or may meet the progressive aggravation of local septic phenomena which calls for amputation, if the life of the patient is to be saved.

The preceding statements can be reduced to the following formulæ:

Bullet wound with punctiform openings = simple development, whatever the type of fracture.

Bullet wound with explosive effects = rapid and fatal sepsis.

Small wound by shell-splinter with fracture of varying extent = gas gangrene or rapidly progressing sepsis in two out of every three cases.

Large wound by shell-splinter = serious sepsis and septicæmia of a more or less rapid type.

To sum up, except in bullet wounds with punctiform openings, sepsis is certain; often it is grave. Therefore, as it is impossible to foresee what the septic

developments will be, it is better in all cases to do a primary operation for prophylaxis and disinfection, as early as the circumstances permit, so as to render the condition aseptic at once.

II. Primary Therapeutic Indications

We will put aside the bullet wounds with punctiform openings, which simply require an aseptic dressing and immobilisation in a plaster casing for at least three weeks, and only consider, as before, the cases under discussion, viz. all the other wounds of the elbow.

Granted that "armed abstention," either by plaster case or splint, is dangerous, and that a primary prophylactic operation is necessary, three possible operations ought to be considered: arthrotomy with or without esquillectomy, resection, and amputation. To one of these recourse must be had; for one should never be content to push a drainage tube through from the wound of entrance to that of exit, a practice both illusory and useless, and always dangerous owing to the false security to which it gives rise.

1. Arthrotomy.—Arthrotomy for simple exploration, done through an incision, close to the outer border of the olecranon on a level with the posterior wound if there is one and completed by a postero-lateral incision on the inside, is a clearing operation sufficient for slight cases, such as parietal fractures, superficial abrasions of a bone, detachment of a chip of the humerus or ulna, or cancellous crushing due to a missile driven into the bone: all of which are wounds, rather than fractures of bone, strictly speaking. But arthrotomy ought to permit the removal of anything that is detached, and the cutting off of what is irregular or has been bruised. In these conditions, even if there is a radiating fissure, arthrotomy done for purposes of disinfection and extraction of missiles,

when performed quite early, is an excellent operation, which gives the best results; the wounded recover almost complete movement, according to my experience of the three cases in which I have used it.

But when the injuries are more considerable, when an intra-articular fracture is present, and when the necessary measures of disinfection and clearing are required over a wider area, arthrotomy is insufficient,

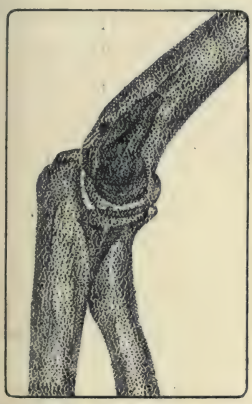

FIG. 23.—Cancellous fracture of the lower extremity of the humerus, the projectile remaining. Primary operation: removal of the shell-splinter, curetting of the bone, and aseptic dressings.

FIG. 24.—Radiograph of the injury fifteen days after operation. Aseptic course. Recovery with retention of movement.

for it does not go to the root of the trouble. It can, and often does, leave in the joint the remains of clothing, splinters of bone and dead tissues, which are direct predisposing causes of sepsis, gas gangrene, arthritis, and above all acute osteomyelitis, often necessitating amputation, and leading to a fatal issue. As a rule it is advisable to complete an arthrotomy by doing esquillectomy.

This is the operation of choice for most surgeons

in the vast majority of cases: esquillectomy limited and prudent, is the expression they always use, just sufficient to avoid the incidence of acute sepsis. In the favourable cases just described, when the injury is very limited, such as the detachment of the olecranon or of the internal epicondyle, it is capable, when done early, of giving an excellent result.

FIG. 25.—Fracture of the olecranon by shell-splinter, treated by simple immobilisation and antiseptic lavage. No operative intervention. Recovery with ankylosis of the elbow. Patient seen in consultation five months after the injury to decide upon the utility of resection, which has been rejected as useless, considering the angle of the ankylosis and the profession of the patient.

But when the damage is more extensive, when a fracture through the epiphysis is concerned, it is almost always insufficient to ensure complete disinfection of the joint. Furthermore, it interferes with the functions of the joint either by ankylosis or by loss of proper movement later. If any infection remains, ankylosis is inevitable, since it causes the cartilage to ulcerate and leaves the inflamed bony surfaces in close contact. As to the loss of the normal movements, this is a necessary consequence of limited unilateral esquillectomy. Ablation of one of the condyles of the humerus destroys the statics of the joint and subsequently interferes with its dynamics: the elbow deviates to one side, and the final result is bad.

In more severe fractures with extensive fissuring, which are in fact the cases of medium gravity, arthro-

tomy and esquillectomy fail to get rid of the septic complications that they are incapable of preventing. In a joint as close-fitting as that of the elbow, simple incision, even when followed by perfect immobility, is less able than in the case of the other joints to prevent or stay the development of acute articular osteitis, which, even in the most favourable cases, tends to become chronic. It is powerless to prevent the necrosis of adherent fragments of bone, whose vitality seemed sufficient at the moment of intervention, but which sepsis has converted into sequestra incarcerated in the ankylosed mass.

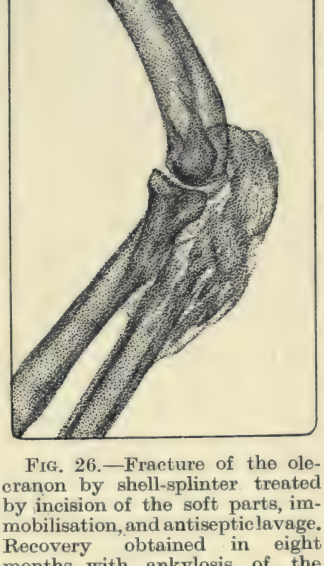

FIG. 26.—Fracture of the olecranon by shell-splinter treated by incision of the soft parts, immobilisation, and antiseptic lavage. Recovery obtained in eight months with ankylosis of the elbow. This case was particularly well suited to primary resection: recovery would have resulted sooner and probably with satisfactory movement. The patient seen in consultation nine months after the injury, before his discharge, submitted to resection which has given a good result, but the power of active movement is limited by induration of the muscles caused by prolonged suppuration and the methods of drainage.

Long after an apparent cure, the elbow remains exposed to relapses of inflammation in the form of intra-articular abscesses and obstinate sinuses, which can only be cured by a late resection. But resection at this stage is a mediocre operation viewed from the standpoint of function. Performed upon chronically inflamed bones, its results are uncertain; I allude to the difficulty

of avoiding ankylosis. On the other hand, even if passive movement can be obtained, there is serious difficulty in regaining satisfactory active movement, which after all is the only useful one. The result usually depends upon the condition of the muscles, which is generally deplorable in the cases under consideration: they are sclerosed and atrophied with indurated and adherent aponeurotic scar tissue, and it is very difficult to restore muscular contractility and anything like the normal suppleness of the tissues.

To sum up, the object sought by means of arthrotomy and esquillectomy can be attained much more easily by primary resection, which is the operation of choice for limited injuries, and which alone is suited for the cases in which there is great destruction of the elbow, and which we are now going to consider.

2. Sub-periosteal Resection.—Immediate resection is, strictly speaking, the type of the clearing operative procedure applicable to all injuries that are not simple parietal fractures or bullet wounds with punctiform openings, and to all cases in which the fracture has upset the mechanism of the joint. Performed in the first few hours or even days after the accident, it permits the removal of organic foreign bodies, fragments of clothing, missiles, and free splinters of bone, together with any other structures that are dead or likely to die. It makes a wound so regular and clean that no sepsis can develop in it; it is really prophylactic against infection, and it banishes the fear of serious complications. Its after-results are very simple, if they are looked after with ordinary care; there is rapid recovery of almost the full range of movement of the joint, after an aseptic healing, and since the patients are men in full physical vigour, with intact muscles, an active new joint is almost always obtained with really excellent functional efficiency.

If the after-care is not what it should be, ankylosis

results; the very result aimed at by the so-called conservative operations of arthrotomy and esquillectomy. Thus, the bad result of a resection is at least equal to the good result of an esquillectomy. Indeed it is generally better, for the ankylosis which is obtained after resection results from fusion of two healthy bones, and therefore the patient is not exposed to the later complications which have been noticed after arthrotomy.

Resection has, however, been much opposed and numerous reproaches have been levelled at it, none of which are justified.

(*a*) To begin with, it is said that resection is not necessary, since injuries of the elbow are mild, and heal easily after arthrotomy. This opinion has only been pronounced hitherto by surgeons at the base who, contrary to what they imagine, have only seen very selected cases. It is well to repeat here that it is a long way from the line of fire to a base hospital, and at these latter only those patients arrive who have been able to stand at least two or three days' journey without developing serious infective complications. Between the wounded in the front line and those who reach the base there is an enormous difference. Those who talk of the mildness of elbow injuries do not realise the number of amputations that these injuries necessitate at the front, especially when resection is not boldly put into practice. And even these figures would only give an inexact impression, for it would not include deaths. It is not sufficiently realised that two-thirds of the injuries to the elbow caused by shell-splinters or the explosive effects of bullets are dangerous to life. Delay in freely clearing out the wound is heavily paid for. Gas gangrene, acute sepsis, arthritis and articular osteitis, lead to early secondary amputation, which the supporters of the supposed mildness of elbow injuries do not bear in mind, probably because they are not

aware of it : nevertheless this fact has to be reckoned with. At almost every medical board at which we see cases that have had amputation of the arm, there are one or two which have been done for fractures involving the elbow-joint. The case-sheet reads : "Gas gangrene, or septicæmia, occurring at the end of three or four days." That is the condition, but primarily it arose from a fracture of the joint, and resection would certainly have avoided both the complication and the amputation.

(*b*) It is also said that esquillectomy is generally sufficient, and that it is a less wasteful operation than resection. It is perfectly true that it is sufficient when the fracture is limited in extent and confined to a single bone. But the avoidance of sepsis at a small cost does not constitute economy. The economy we require is not so much concerned with the bone as with the function of the joint. Now, ablation of a condyle of the humerus, or of a part of the ulna, certainly gives a deplorable functional result. The forearm is in bad position and either varus or valgus occurs. The only way of procuring a good functional result with certainty in this kind of case is to perform a typical resection. I will return to this point later. When two bones are fractured, esquillectomy is only apparently economical. It sacrifices less in width, but just as much in length ; and it is this latter point alone which is important from the point of view of the function of the joint.

(*c*) It is also objected that resection of the elbow is more difficult than arthrotomy, and since war operations are performed by surgeons who have no great experience of bone surgery, they should preferably be simple.

I confess that I cannot understand this reasoning. There are not two kinds of surgery, that of the ignorant practitioner and that of the experienced : the latter alone ought to be the operators at the front. It is

easier to perform a resection at the elbow than to do a laparotomy or tie some large vessel. *The surgeon engaged in the difficult surgery at the front ought to be capable of doing a sub-periosteal resection of the elbow ;* if not, how, I ask, can he perform his daily tasks ? It is his right and his duty to do the operation which appears best from the point of view of the preservation of life and recovery of function.

(*d*) It is further stated that in times of stress it is impossible to supervise the post-operative stages of a resection, and that this is vital. As a matter of fact a resection of the elbow is much more easy to look after than an esquillectomy, which is always liable to the onset of infection. A resection runs an aseptic course, and as a general rule there is no need for further operation, while arthrotomies which suppurate frequently require fresh incisions and always call for daily dressings. In a front-line ambulance a case of resection gives much less anxiety than an arthrotomy. And later on, when the time comes for daily movements, it is very easy to spare two or three minutes daily to perform them. I have always found time to do so while in charge of a large ambulance at the front ; at a base hospital it is simply a matter of willingness to do it, and of organisation.

(*e*) Another objection is that resection is not economical, because it leads to the removal of fragments, which might have been preserved by a waiting policy, and the preservation of which would have diminished the loss of substance.

To me this appears ridiculous. A properly performed resection does not mean a final loss of bone ; if it leads to large sacrifices, it is because the damage is excessive. I do not understand why a T-shaped fracture of the humerus with injury to one of the bones of the forearm, which is a frequent condition, should necessitate too extended a resection. Out of eighteen cases of primary resection, I have never been led to

remove more than was necessary. The whole point is to know if the operation will give a good functional result. Then, if it is correctly performed, that is, strictly sub-periosteally, and if the after-treatment is efficient, it always leads to a satisfactory recovery of function. There is no need to quibble with words: when a fracture of the epiphysis is in question, the most economical operation is a typical resection and not esquillectomy; because the former, by sacrificing more in width, but not in length, is definitely much more preservative of function. When there has been extensive destruction of shaft and epiphysis it is more economical than any other operation, because it will save the limb, its functions, and, sometimes, life itself. In eighteen primary resections I am convinced that I have avoided at least four if not six amputations of the arm and one disarticulation at the shoulder. Thanks to primary resection at the front, I have not amputated once for fracture of the elbow,

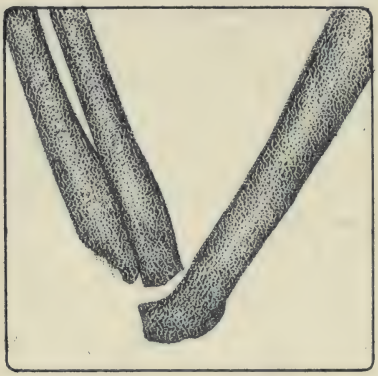

FIG. 27.—Result of primary resection for explosive destruction of the humerus and ulna by shell-splinter. No feverish symptoms. Complete cicatrisation in thirty-five days; perfect restoration of function; complete active extension; flexion, pronation, and supination normal. The patient can carry 15 kilos with the arm raised and can pull 150 kilos with the hand of the injured side. Radiograph taken at the end of eight months; the regularity of the contour of the bones is noticeable. Compare this figure with figs. 7, 8, and 9, which relate to the same case: there is no excessive periosteal bony new growth, as in the secondary or later cases of resection shown in figs. 33 and 47.

and I have not lost a single case. I think, therefore, that I have a right to say that resection is an economical operation.

(*f*) The most important objection is that resection gives bad functional results, because it leads to a flail-limb, which is of much less value than an ankylosed joint. Ankylosis in good position is undoubtedly more useful than a flail-limb. But even the latter with a normal hand is more useful than the finest artificial limb; moreover, it must be admitted that a resection that has called for enough loss of tissue to cause a flail-elbow in all probability saved the limb from amputation. In an operation such as resection of the elbow bad results can only be due to one of three causes: too great sacrifice of bone, necessitated by the extent of the injury (more than $2\frac{1}{2}$ inches of the bones forming the joint), bad operative technique, or faulty after-treatment; of these the two last points are the most important.

FIG. 28. — The same patient as fig. 27. Radiograph of extension in profile: it is noticeable that the forearm is flexed on the front of the lower extremity of the humerus.

Ollier obtained satisfactory recovery of function in patients from whom he removed four inches of the bone, and, like others, I have personally seen similar cases. It can be affirmed, then, that if the results are bad, if flail-limbs are found at the base hospitals, one of two things has happened. Either the operator has been confronted with considerable injuries, in which case he has been well-advised in performing resection, since the operation has in spite of all been conservative; or the injuries were limited but the

technique was bad, in which case the fault is not that of the operation, but of the operator himself, or the surgeon who directed the after-treatment. These last factors, bad technique and bad supervision of the after-treatment, are undoubtedly the most frequent causes of failure. Whatever indeed may be the extent of the damage, strictly sub-periosteal operation in a young man with powerful muscles ought

FIG. 29.—Functional result obtained by primary resection of the elbow: photograph taken six months after the injury. The patient has been shown to the Société de Chirurgie. The radiographs 7, 8, 9, 27, and 28 relate to this case.

always to give a satisfactory result, and ought not to end in a flail-joint. This flail-elbow, without the least power of movement, is primarily due to complete muscular insufficiency. When a primary resection is performed, the muscles are vigorous and strong, nothing has atrophied them; when they contract, they bring the newly formed articular surfaces into close contact with one another; playing the rôle of ligaments they articulate the new joint, so to speak, and allow it to work freely and with precision, even if the resection has been an extensive one. Among the eighteen patients upon whom I have done early resection, a large proportion have had considerable amounts of bone removed; none have got a powerless arm; and in all of them, thanks to their muscles, the active movements of the new joint have been good.

One of them, after losing four inches of bone following destruction of the elbow (figs. 30 and 31), can carry more than 10 kilos (20 lb.) with his arm extended; another draws a hand-cart loaded with 150 kilos with the hand of the resected limb. It is interesting to

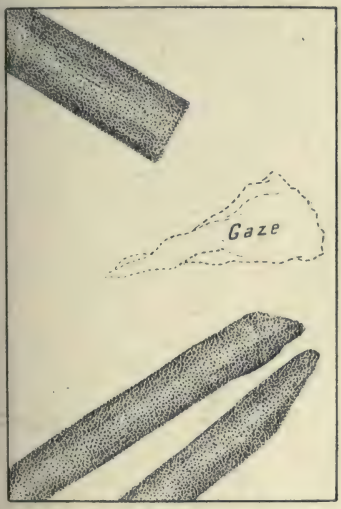

FIG. 30.—Early secondary resection (fifth day) for explosive destruction of the elbow. The splinters having been removed subperiosteally, the end of the shaft of the humerus has been cut straight through with the saw. Radiograph taken twenty days after operation. Complete recovery in sixty-five days after the operation.

FIG. 31.—Radiograph of the same elbow three months after resection, showing the periosteal new formation on the bony extremities. After a year, the patient, in spite of the extensive loss of substance, has a perfect restoration of flexion, extension, pronation, and supination.

note that this man was forty-two years of age when the resection was done, which proves that, from the point of view of recovery of functional power, age is not so important as is imagined. In consequence of what I have seen, I think that the flail-elbow is due to a faulty technique, or to an absolute want of post-

operative attention ; it is met with in consequence of its being forgotten that the patient requires supervision after resection, and should not be left to his own resources during the months that he carries his arm in a splint.

In conclusion, resection is an excellent operation when one knows how to do it, and when one takes the trouble to direct the after-treatment according to the principles of orthopædics and physiology. It should be done at once for all severe fractures, because it is the best method, if not the only one, of preventing or checking infection, and thus avoiding amputation ; and in wounds of moderate gravity, because it is the only way of preventing ankylosis and of preserving the normal mobility of the joint.

Moreover, primary resection is to be preferred, because it does away with infection, which would injuriously affect the progressive regeneration of bone, and because it permits of complete muscular integrity, which ensures a good functional result. After a primary resection, the extremities of the bones are restored with regular, smooth, and clean outlines and mobility is much more easily obtained than after secondary resection in which the periosteum, inflamed and feeble, proliferates so wildly that the post-operative treatment becomes extremely difficult.

The physiology of the joint corresponds with the anatomical condition, and this can be studied by radiography. I have examined a dozen resections under the screen : the play of the joints resulting from aseptic resection is infinitely more supple, more varied and delicate, than it is in those in which resection is done when sepsis is present. The gliding of the bony surfaces is softer and more regular and is effected in one of three ways : sometimes the extremities of the bones of the forearm move in the normal plane, end to end with the humerus (figs. 30 and 31) ; sometimes they pass in front of the lower extremity of the

humerus, which is hollowed out to form a cup like a reversed olecranon fossa (figs. 27, 28); and at other times the bones of the forearm slide a little backwards, and when flexion occurs are almost in contact with the posterior surface of the humerus. With each of these types, of which the two former are the most frequent, the functional appearance is equally satisfactory. Briefly, the radioscopic study of new joints at the elbow demonstrates that after a correct and early operation, the physiological restoration of the joint can be reasonably counted upon; which is one more argument in favour of primary resection.

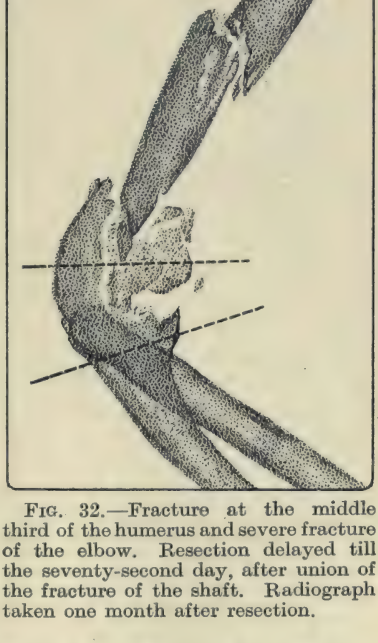

FIG. 32.—Fracture at the middle third of the humerus and severe fracture of the elbow. Resection delayed till the seventy-second day, after union of the fracture of the shaft. Radiograph taken one month after resection.

This operation has only one contra-indication, viz. the presence of a fracture of the shaft of the humerus, or of the bones of the forearm about their centre. In these cases it is better to wait for the consolidation of the fracture and then to perform a secondary resection. This delayed operation has yielded a very good functional result in my hands (figs. 32, 33).

3. AMPUTATION.—There is no indication for primary

FIG. 33.—The same patient as in fig. 32 : result of a delayed resection. Radiograph at the second month. The fracture of the shaft is united; there is a mass of new bone at the epiphysis; the functional result is good; but there is some difficulty in obtaining satisfactory flexion because of the bony mass at the front of the joint. However, three months after resection active flexion reached 90 degrees, and extension is complete, but pronation and supination are slightly limited.

amputation in fractures of the elbow when the vessels and nerves are not severed, extensive resection being sufficient even in the most complex fractures. Neither is it indicated as a secondary measure, early resection preventing all the complications which might make it necessary.

The indications for operation in fractures of the elbow can be summed up as follows :

Ablation and immobilisation in plaster for punctiform bullet wounds. Limited arthrotomy and esquillectomy for parietal fractures and cases of cancellous crushing by a missile embedded in the bone. Primary resection for all fractures into the joint, and for all bony injuries due to explosive injuries.

Secondary resection for fractures of the elbow complicated with fracture of the shaft, above or below the articular injury. There is no indication for amputation provided that the vessels and most of the nerves are intact.

III. Operative Technique

(*a*) ARTHROTOMY ought to be performed by two vertical incisions passing as far as possible, one in the space between the supinator longus and the outer head of the triceps, descending thence towards the base of the olecranon ; the other over the internal condyle. There should be no hesitation to make the incision free, and in case of need to convert it into the incision for resection indicated below. Esquillectomy should be done with the rugine, followed by curetting the cancellous bone, so as to remove all suspicious tissue. The arm should be flexed so as to make the incision gape and give more room. The wound is plugged with aseptic gauze, and the limb carefully immobilised. For the first few days it is put in a well-padded wire splint, moulded to the limb and with the wrist extended and the fingers free.

(*b*) RESECTION ought to be done according to very precise rules, all of which are important, though scarcely mentioned by the treatises on operative surgery. The principal point is to aim at following the classical steps of the operation in every particular. There should be no departure from the regular method in consequence of the existence of wounds, either of entrance or exit. From start to finish the operation should be carried out as if they did not exist. It is needless to apply an Esmarch's bandage, and it is better to arrest bleeding as one goes along.

The Incision.—Having tried all sorts of incisions, I advise the angular extero-posterior or bayonet-shaped incision of Ollier, which gives plenty of room and does not divide muscle. The median-posterior and the two lateral incisions gape at the end of the operation and form button-holes ; they are liable to cause retention of the discharges and do not give sufficient drainage. The bayonet-shaped incision commences two inches and a half above the projection of the external

condyle and runs along the postero-external edge of the humerus; thence it is directed obliquely downwards and inwards to the base of the olecranon, where it bends sharply to follow the posterior edge of the ulna for two inches; it does not divide any muscle, and leaves the fibres of the triceps untouched.

Denudation of the Bones.—When the incision has reached the bone, the knife is discarded for the sharp rugine, which alone is capable of doing, as it should be done, the first, and, from the point of view of the future, the most important part, of the operation, viz. the denudation of the olecranon and the detachment of the insertion of the triceps. By degrees, keeping close to the bone and actually cutting into the bony tissue, the rugine completely detaches the tendon and the periosteum. The denudation of the internal condyle of the humerus and the liberation of the ulnar nerve are then undertaken; this is neither difficult nor dangerous if the rugine is well under control. The instrument must be kept scrupulously in contact with the bone and the groove between the epicondyle and the olecranon carefully cleared.

FIG. 34.—Bayonet-shaped incisions for access to the elbow-joint.

The rugine will ere this have met with splinters and bony débris, and the operation cannot therefore correspond to any written description. The entire attention should be given to clearing the joint of detached fragments of bone. Nothing need be torn away: each splinter of any size is held with forceps while the rugine strips off its periosteum. After fragments have been removed, the systematic freeing of the extremities of the bones is undertaken: first, on the inner side, until the tip of the epitrochlea has been cleared well down on to the ulna, detaching the

muscular attachments found there; and then the external condyle of the humerus and the head of the radius. Then the edges of the sigmoid cavity of the ulna are cleared, and the insertion of the brachialis

FIG. 35.—Fracture of the epiphysis of the humerus by shell-splinter. Primary resection.

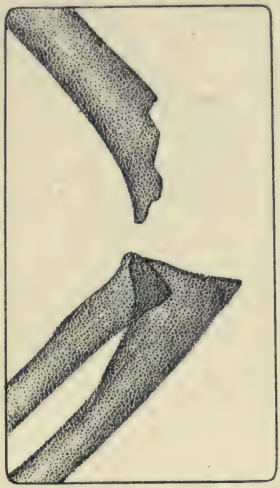

FIG. 36.—Radiograph taken four days after resection. Cure rapid with recovery of active flexion, extension, pronation, and supination. Complete cicatrisation in forty-five days.

anticus into the coronoid process, when the joint can be held wide open and the bones dislocated backwards.

When the rugine has freed all the bony surfaces by detaching the muscular insertions without cutting either them or the layer of periosteum to which they are inserted, the time has arrived for making the final bone sections. This is regulated by the line of fracture and the extent of the bony damage, but the object should be to make the section of the humerus through the thickness of the condyles, or just above

them where the shaft commences to widen. A section through the epiphysis just below the level of the epicondyle is the best if it can be managed.

In the bones of the forearm the section ought to be

FIG. 37.—Fracture of the extremities of both bones of the forearm by shell-splinter, treated at the front by incision and immobilisation. At the end of fifteen days the patient reached me in a condition of full sepsis with high temperature and an enormous elbow-joint. The above radiograph was taken at that moment. Resection of the bones of the forearm was performed forty days after the injury.

FIG. 38.—The same after recovery, two months later. Extension is complete, but it is only effected by the triceps to 45°; flexion complete but ending in a sudden slipping of the ends of the bones of the forearm over the trochlea. A rather extensive resection of the epiphysis of the humerus would doubtless have had a better result by facilitating the adaptation of the epiphysis.

carried below the coronoid and through the neck of the radius.

Very often the articular end of the humerus is only fractured on one side, and the broken fragment carries with it a thin plate of the shaft: enough of the articular end remains on the sound side to enable the section to be through the epiphysis, which is sufficient if the

periosteum is preserved, for this latter will regenerate a new epiphysial mass.

Certain fractures may necessitate a section through the shaft : the procedure should then be confined to removal of the fragments without troubling about the shape of the bony extremities remaining. It is quite unnecessary to do anything for the fissures which divide the shaft longitudinally as if it were split. After the removal of the epiphysial fragments, everything is perfectly repaired (see figs. 7, 8, and 9). At most, the sharp ends may be smoothed off with cutting pliers.

When the fracture separates the epiphysis from the shaft, a large fragment is almost always found extending along the latter : of all the fragments this alone should be preserved ; the others are carefully stripped of their periosteum and removed. In this manner we preserve in an aseptic cavity the requisites for periosteal regeneration of bone, the completeness of which is surprising. The lower end of the injured shaft should always be freed and clipped off, for there the bone is of a reduced vitality and easily necroses.

But if it is necessary to be sparing in the removal of bone on the diaphysial side of the epiphysis, it must be realised that economy, as applied to resection in fractures localised to the epiphysis, is a mistake from the point of view of the future function of the injured joint. The results of a very limited removal are much less satisfactory than those of *free* resection : when the articular surfaces can come into close apposition immediately, all the benefit of resection as regards drainage is lost, and the functional result is endangered by the risks of ankylosis.

Moreover, if the movements of pronation and supination are to be obtained, complete removal of the head of the radius is essential. This is a view of the question that the partisans of hemi-resection do not take into consideration. Cases in which supination is

retained after that operation are very rare indeed; I have never seen any myself.

In a word, except in fractures where the loss of bone, shaft, and epiphysis in one of the articular extremities is much too considerable, it is better not to adopt hemi-resection either of the upper or lower half of the joint: they do not drain well, it often becomes necessary to complete the resection some days later, and besides, the functional result is always inferior to that obtained by complete resection. The reason of this is easy to discover: one of the articular ends being still covered with its cartilage cannot be moulded by movement, and the other is obliged to adapt itself to surfaces which are too complicated for its rudimentary shape; it has to do all the work of forming the new joint by itself, for which reason adaptation is more difficult and less perfect. In short, the ideal bone section is similar to that in a typical resection for tuberculous disease.

IV. After-Treatment

1. **After Arthrotomy.**—A dressing of aseptic gauze is loosely packed between the bony surfaces round a small drainage tube inserted in the openings in the capsule. If the operation has been done early and if the clearing out has been complete, the joint ought not to suppurate, and through and through drainage is as unnecessary as is the use of antiseptics and lavage.

The chief desideratum in order to obtain a successful result is rigid immobilisation.

(*a*) This, however, should not be kept up for long, if all goes well: at the end of a week, if there be neither temperature, pain, nor oozing, movements should be commenced and attempts made to restore the free play of the joint.

Consequently it is needless to use a plaster case if the patient remains under observation. The limb

should be placed in a wire or aluminium splint, with the elbow at a right angle and the wrist slightly extended; the dressing should not be changed till the third day if possible, and then the drainage tube should be removed without touching the gauze.

Two days later the gauze should be removed and replaced by a smaller quantity. Two days later the dressing is repeated and movement begun, after which the splint is reapplied.

From this time forward regular daily movements of the joint are carried out, the limb being kept at rest during the night only.

Recovery occurs in one or two months.

(*b*) If, on the contrary, the exploratory arthrotomy has not been done early enough, or if foreign bodies, missiles, or splinters have been left behind, the wound suppurates freely and the treatment differs.

Two groups of cases present themselves for consideration.

The first is simply one of profuse suppuration without constitutional symptoms; after employing radiography to ascertain the cause (missiles, splinters), typical resection is, in my opinion, the indication, but this is only my personal opinion, and treatment may be limited to immobilisation in a plaster casing which will permit dressings to be applied without moving the joint or causing pain. There is no call to try to preserve the joint movements, for, in consequence of the suppuration, the joint is doomed to ankylosis. Treatment may be limited to rigid immobilisation, avoiding all movement until the infection has disappeared.

For the purpose of immobilisation a casing should be made with plaster bandages as follows: one bandage encircling the middle of the arm; another embracing the forearm, the wrist, and the slightly extended hand; two metal brackets to form a bridge, one on each side and a little to the front. This plaster casing is easy to make and to supervise, and fulfils the neces-

sary purposes. The forearm should be flexed at a right angle in the semi-pronated position, thumb upwards.

If suppuration of the joint is accompanied by constitutional symptoms, if there is a missile in the joint or splinters that requires to be removed, the best plan is to perform immediate resection. This is done in the manner indicated above: if the wound is left wide open, it will quickly become aseptic, and generally movements can be commenced at the end of a week or a fortnight after suppuration has ceased and the patient is free from fever. When the treatment can be well carried out, these "intra-febrile" resections give good results. I have done eight for war-wounds and have obtained seven good results, and one moderate one; the latter is getting better with the aid of massage, hot baths, and daily exercise.

2. **After Resection**: Dressing.—After the joint has been cleared and the elbow bent at an acute angle, the wound is dressed without putting in any sutures. If desired, a drainage tube can be passed along the track of the missile; it goes without saying that this track is first opened up and cleaned by the curette, and that all débris is clipped away carefully. A little aseptic gauze can be used instead of a drainage-tube. The cavity of the joint is stuffed with gauze, without using lavage or any antiseptic. An absorbent dressing is placed on the wound and the elbow is immobilised in a wire splint, the hand being slightly raised with the thumb upwards.

As the wound sometimes oozes a good deal, it is best not to use the plaster apparatus, which would soon lose its shape and rigidity owing to the soaking by the discharges.

Later Treatment.—If possible, the dressing is left untouched for seven or eight days. At the end of that time its removal causes less hæmorrhage than if it were done sooner. But often there is oozing of

blood-stained serum which may necessitate its earlier renewal. In that case the outer layers only are changed. An assistant holds the limb firmly, with one hand on the humerus and the other supporting the fore-arm, and upon him depends the amount of pain caused by the dressing. When the gauze is removed from the joint cavity, it is best to give the patient a whiff of ethyl-chloride ; a painless dressing is always better done. Later dressings will be done at longer intervals if one does not commence movement at once.

Sunlight Therapy or Hot Air.—Whenever the weather permits, it is beneficial to expose the wound to sunlight from the fourth or fifth day onwards. Its effects are marvellous. A quarter of an hour's sitting is sufficient to rid the wound of all the small sloughs which are seen upon it, especially at the first dressing, and to give it a healthy red appearance. After three or four sittings, the oozing completely stops and healing is proceeding rapidly. The muscles progress admirably.

If sunlight is not available, hot air can be directed over the wound for five minutes at a time : the effect is less rapid, but is none the less real.

Movement.—As soon as the patient has a normal temperature and is free from pain, the surgeon himself commences active movements, gently performing extension, flexion, pronation, and supination.

The aim should be never to produce pain which will put the patient on the defensive. After a few minutes of movement the limb is replaced in the splint. At the end of from a fortnight to three weeks, the splint is abandoned and the limb put up in a well-applied sling. After that the patient is left for some hours daily without the sling, so that when he tries to keep his forearm raised and flexed, he is bound to attempt some slight active movement. Soon he will begin to gain confidence in himself and to work

at it himself. Little result is obtained at first, but by advising him to try several times in the course of each day, progress is gradually made.

In the early days the recovery of active movements is much facilitated by compressing with the fingers the parts immediately above the elbow, thus giving more fixity to the ligaments of the joint, and allowing muscular action to be more easily effected. For this purpose I am accustomed to grasp the anterior surface of the arm with both hands, as is shown in fig. 39. The result is immediate: the patient begins to flex his forearm, gains confidence, and thenceforward works with a will.

FIG. 39.—Method of commencing active flexion. The fingers are pressed over the new joint and give more power to the ligaments; active movement, which is not performed when the patient is left to himself, is effected to the extent shown in the second diagram when the elbow is squeezed.

In order to practise extension it is absolutely necessary to place the arm in the horizontal position, olecranon upwards, and to order the forearm to be raised. If that exercise is not carried out, the triceps does not recover its contractile power, and the movement of extension remains purely passive (see fig. 40).

It goes without saying that massage of the biceps and triceps should be commenced early. As soon

as flexion and active extension reach a point between 60° and 80°, all passive movement is abandoned and the patient does everything for himself. This daily task is one of patience to which he lends himself very readily if the elbow is left two or three hours at a time exposed to the sun. He becomes interested in his arm, follows its progress attentively, and learns how to work his joint. When this has happened, one can say that success is assured; but even then one should not lose sight of him: his efforts to go too fast must be curbed, and his desire to hurry must be restrained. He must learn that as soon as his move-

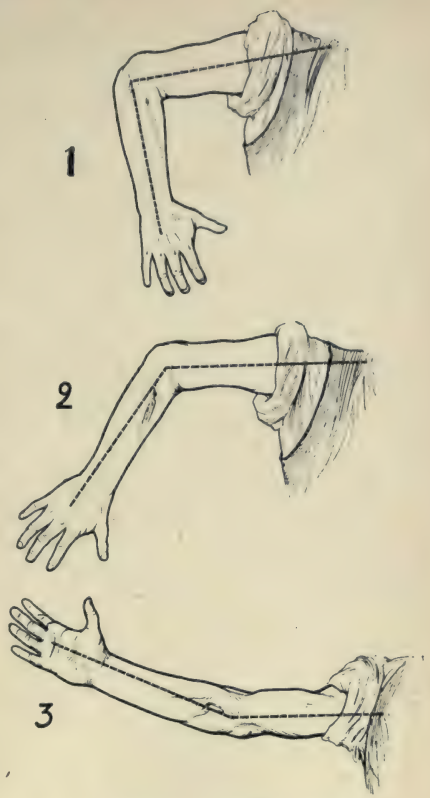

FIG. 40.—Method of making the patient perform active extension. This exercise will be combined with massage of the triceps. Comparison of diagram 3 with the two upper ones shows the difference between active extension and the passive extension occurring upon relaxation of the flexor muscles. The photographs were taken from a case which had been resected three months previously.

ments excite the least pain they must be stopped, and at times the joint must be immobilised again for some days so that it may be at rest. When a patient after resection complains of cramps in the muscle of the forearm, it is because there is periosteal irritation which tends to ossify the insertions of the muscles and demands rest. I never hesitate under these circumstances to put the limb in plaster for a week: much time is gained by acting thus on the first warning.

For all these reasons mobilisation cannot be effected by mechanical means, and mechano-therapy is of absolutely no value after resection. It is always a disadvantage.

In a word, the patient himself must be made to collaborate in his own cure by calling upon his goodwill and his patience; and ankylosis and a flail-elbow will be avoided by inculcating these precepts in him.

V. Evacuation of Patients with Elbow Wounds

Patients wounded in the elbow ought not to be evacuated unless they have a bullet wound with punctiform openings; all the others should be operated upon at the front as early as possible. They should only be evacuated early in circumstances of extreme pressure, and then ought to be left at the first surgical *relai*.

Those who have had arthrotomy done for slight injuries can be evacuated without danger after the third day if they are immobilised in a travelling plaster splint, the description of which will be given later on. The best time for evacuation for them is the eighth day, after the first attempts at movement have been made. Those who have been resected can be sent down without danger towards the fourth or fifth day. but the best time for them is about the fifteenth day, when the healing process has made good progress.

On their departure, each should have a detailed

statement indicating the stage of treatment reached, whether movements have been commenced or not, and giving suggestions upon the after-treatment.

Travelling Splints.—For the journey the limb will be immobilised in a large plaster casing covering the posterior and external surfaces of the limb, extending from the point of the shoulder to the lower end of the metacarpus. A slip of the splint is bent down into the palm between the thumb and the second metacarpal bone to form a strap, which fixes the splint and prevents it from slipping. The casing should only cover half the circumference of the limb. It should be made with twelve thicknesses of tarlatan. A cut is made just opposite the elbow to allow the splint to adapt itself to the flexed joint. The limb is semi-pronated and flexed at an acute angle, with the thumb upwards. The plaster splint is applied to the limb by a gauze bandage. As soon as the plaster is dry, this bandage is removed for fear it might become too tight, and is replaced by another, or, what is better, by three pieces of strapping, one on the arm, one on

FIG. 41.—Travelling-splint for wound of shoulder. Between the dressings this casing can be used for permanent immobilisation.

the forearm, and one at the level of the hand. Lastly, a sling is applied to support the forearm and elbow. On the patient's arrival this apparatus is removed; the journey should not exceed forty-eight hours' duration.

VI. Treatment of Patients seen late or after Evacuation

1. A PATIENT WHO HAS BEEN BROUGHT IN AFTER SOME DELAY, ARRIVES AT THE AMBULANCE AT THE END OF 24 OR 36 HOURS.—The elbow is swollen and painful, and sloughing muscle protrudes from the wound, pouring out blood-stained fluid. Immediate subperiosteal resection is the best treatment; it stops infection at once, avoids amputation, and ensures rapid recovery without sinuses or muscular atrophy. This result is obtained without the repeated operations which are so often necessary with every other method of treatment. I have had patients completely healed in forty days.

The after-treatment ought to be carried out on the lines laid down above.

2. A PATIENT IS EVACUATED AFTER CORRECT TREATMENT.—(*a*) *A case in which immediate arthrotomy has been done for parietal fracture or removal of a foreign body in contact with the bone* heals rapidly. At the end of a fortnight, immobilisation is abandoned and movements are commenced.

(*b*) *In the case of a patient arthrotomised for comminuted fracture, and doing well*, which is exceptional, ankylosis should be promoted by rigid immobilisation, and resection performed later. Premature attempts at movement in these cases may provoke symptoms of severe sepsis. While waiting for the final orthopædic operation the muscles should be gently massaged to keep them in good condition.

What position should be chosen for ankylosis? Classically the acute-angled position is the one of choice.

It permits the best use of the hand in private life, but it is not the position which gives the greatest strength to the hand. For manual workers a position at an obtuse angle (100°) should be sought for. According to the teachings of experience, that is the most useful position for the workman.

The objection is made that the workman is a private individual before being a workman, and that flexion at an acute angle is better in the case of the right arm, as it is with the right hand that one eats, dresses, etc. But as a matter of fact the first business of anyone wounded in the right arm is to become left-handed, when this objection falls to the ground.

There is no fixed rule and one had best follow the classical rule. But it is well to know of the argument so as not to worry about a joint which unites at a slightly obtuse angle ; that position is not a bad one and ought to be left, unless the other arm is powerless or has been amputated, in which case the only good position is at an acute angle.

Which is the best time for an orthopædic resection if the patient's profession calls for one ? It is not well to wait too long because of the condition of the muscles, or to interfere too soon because of periosteal irritation which must be left to settle down : from eight to ten months seems a suitable period.

It must not be forgotten that in certain callings requiring power in the arm, a painless firm ankylosis in good position should not be interfered with.

(*c*) *A limb that has been resected* ought not to be put up in a splint or an interrupted plaster casing and left to the tender mercy of any dresser to look after ; it is as meritorious for a surgeon to supervise the formation of a new mobile joint as to do a brilliant resection operation.

In this kind of surgery, the operation itself is only one part of treatment : it is criminal to take no interest in the after-treatment because one has not

oneself performed the first part of it. This after-treatment ought to follow the rules given above.

3. A PATIENT INSUFFICIENTLY OPERATED UPON ARRIVES WITH PROFUSE SUPPURATION.—The affected part must be radiographed at once, and according to

FIG. 42.—Fracture of shaft and lower epiphysis of the humerus treated at the front by limited esquillectomy, evacuated on the twenty-second day in a serious septic condition with adverse local symptoms. Amputation appeared necessary.

FIG. 43.—The same patient as fig. 42. Sub-periosteal resection with esquillectomy by the rugine had been performed on the twenty-fifth day. The radiograph shows the condition eight days later. The periosteum is already visible beyond the shaft.

the indications furnished by the presence of missiles or splinters, intervention must be practised.

Any missile must be removed.

Any suppuration which is of bony origin is the product of osteitis rather than arthritis. It must be

treated by operation. Multiple incisions doubtless sometimes succeed in obtaining the desired result, but these successive operations end by leaving ankylosis with sinuses, after severe pain, and a limb which is wasted, indurated, and furrowed with adhesions and scar tissue.

It is best to perform subperiosteal resection at once.

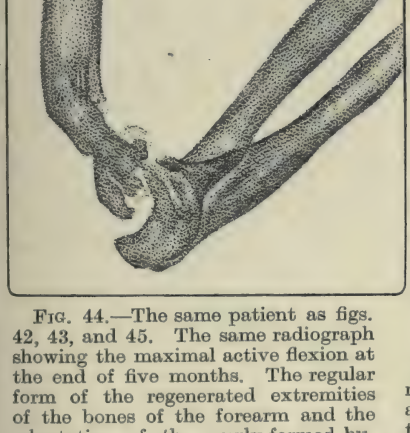

FIG. 44.—The same patient as figs. 42, 43, and 45. The same radiograph showing the maximal active flexion at the end of five months. The regular form of the regenerated extremities of the bones of the forearm and the adaptation of the newly-formed humeral callus are noticeable.

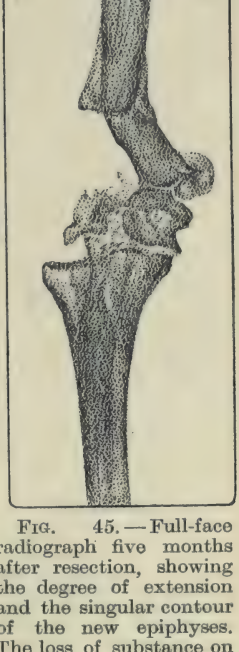

FIG. 45.—Full-face radiograph five months after resection, showing the degree of extension and the singular contour of the new epiphyses. The loss of substance on the inner side is probably due to the fact that the esquillectomy performed at the front was not done sub-periosteally.

If this be done exactly according to the rules given above, it immediately arrests infection and stops suppuration; after which one may obtain a remarkable anatomical and functional recovery (see figs. 44 and 45). Ollier himself had a tendency to prefer this late resection to the earlier

operation, which he dreaded on theoretical grounds, because he feared an insufficiency of periosteum which I have never met with after primary resection. I have done secondary resection eight times, with seven good results and one passable one which is improving. While preferring primary resection, the results of which are much more perfect

FIG. 46.—Casing, with spring for mobilising the elbow for use with timid patients or for those who have a flail-joint. In this latter case the apparatus will be removable to permit massage and exercise.

anatomically and physiologically, I consider secondary resection, early or late, an excellent operation. Technically in these cases it is well to be warned against a troublesome incident which may possibly occur in resection: while section of the humerus is being done, if one is not careful, the assistant in retracting the soft parts in front may reflect too much of the inflamed

periosteum and the denuded shaft of the bone projects prominently in the wound. This accident, which is easily avoided, is of no serious consequence; all that is needed is to repair it by fixing the periosteal sheath to the posterior muscles with a few catgut sutures.

As to the post-operative treatment, one of the troubles is combating the stiffening and inflammatory thickening of the muscles. A very hot bath, for half an hour daily, followed by gentle massage, with attention to movements, gives the best results in these cases.

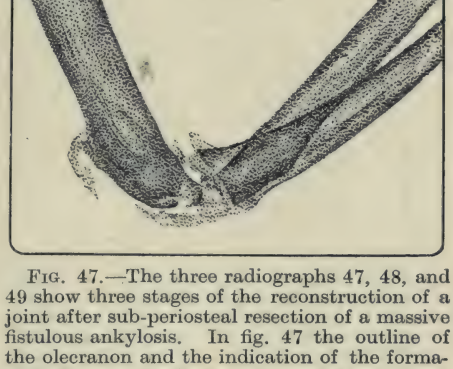

FIG. 47.—The three radiographs 47, 48, and 49 show three stages of the reconstruction of a joint after sub-periosteal resection of a massive fistulous ankylosis. In fig. 47 the outline of the olecranon and the indication of the formation of an epiphysis to the humerus are noticeable.

4. A PATIENT IS SEEN WITH A FLAIL-ELBOW.—This bad result is due either to a resection with very extensive loss of bone, or to bad technique in the operation itself or its after-treatment.

If the wound has not closed, a plaster casing with a spring must be made so as to get as complete an apposition of the bony extremities as possible, while permitting movement. This apparatus is easily made by two circular bandages, one for the arm and the other for the forearm, each about four inches in depth, strengthened by two springs of the shape shown in fig. 46. This apparatus should be left in position for twelve days, and then taken off daily for an hour

or two. To do this it is only necessary to cut the upper bandage down the back, and the lower one down the front, when the apparatus becomes detachable.

The patient takes a very hot local bath daily of about half an hour's duration to make his muscles supple. Then after careful drying he is massaged, and if possible has an hour's sun bath. At the end

FIG. 48.—In this figure the olecranon is hidden behind the humerus and is invisible, but the formation of the humeral callus is very clearly seen.

FIG. 49.—Here are seen the olecranon, the coronoid process, and the trochlea. At this time (four months) active flexion reached 70 degrees, active extension was almost normal, and pronation and supination were complete.

of two or three months of this treatment the muscles will have become supple, and really support the loose new joint, so that better functional use becomes possible.

It is a great mistake, then, to abandon flail-elbows, or to fit them at once with artificial joints. The first

thing necessary is to restore the contractile power of the atrophied muscles. In this way unhoped-for success can be obtained. By this treatment I have restored useful active movements to a patient who had lost nearly five inches of the humerus, and whose arm hung useless at his side. If massage fails, before resorting to artificial limbs one should try to get ankylosis by refreshing the bony surfaces and suturing them, following this by prolonged immobilisation. It will still be possible to make a sheath of muscle and aponeurosis round the capsule by operation; reconstitution of the triceps ought thus to be quite possible.

A permanent jointed apparatus with a double armlet should be kept as a last resource in case of failure, or for patients who refuse further operation.

5. A Patient is seen with Ankylosis and Sinuses. —Immediate resection ought to be performed. It should be done widely, and the line of bone section should go high enough up the end of the humerus, and the whole of the sigmoid cavity and the olecranon should be sawn off. These are the extensive resections which give the best functional results, so long as the line of section runs across the humeral epiphysis. To ensure the recovery of supination, I am in the habit of dividing the radius with cutting pliers a little lower than the ulna; in that way the required mobility is much more easily obtained.

It is necessary to operate in the same way for vicious ankylosis and on those cases in which orthopædic resection is indicated (see p. 97). After resection, movement should be commenced in ten days and pursued according to the rules already given.

If the precepts of the sub-periosteal method are followed accurately, remarkable anatomical and functional results will be obtained (see figs. 47, 48, and 49). Up to the present time in wounds of this kind I have had twelve good results out of twelve operations undertaken for orthopædic reasons.

CHAPTER IV

WOUNDS AND FRACTURES OF THE WRIST

I. Anatomical Types and Clinical Course

From the point of view of classification there are three etiological, three anatomical, and two clinical varieties of gunshot wounds about the wrist.

Etiologically these are :—

The bullet wound with small skin orifices, very limited fracture and tunnelling of the bone without comminution, which recovers quickly and well with partial ankylosis of the carpus.

The small blind wound caused by a shell-splinter, a tiny hole with contused edges, in appearance nothing, but leading rapidly to an acute arthritis of the wrist.

More or less considerable destruction of the carpus, the result of a bullet fired at close range or of a shell-splinter. This type is very common, especially as a large wound on the dorsum of the wrist.

Anatomically the injuries may be purely carpal, especially in the two first groups mentioned above. They affect the radius or ulna fairly seldom and very often are carpo-metacarpal.

Clinically, the course is usually mild at first : these wounds scarcely ever give rise to gas gangrene or septicæmia, because, being wounds of exposed parts of the body, they hardly ever contain fragments of clothing, and because, being wounds involving

skin and bone only without extensive damage to muscles, they do not provide the conditions essential to the development of severe infection.

The danger is suppurative arthritis, the course of which is sometimes very insidious, but which demands rapid action for its treatment.

Many widely gaping wounds, freely exposed to the air, heal well, but considerable loss of power persists in consequence of the destruction of tendons, displacements of the metacarpal bones and fingers, which often necessitate subsequent corrective amputations.

II. Primary Therapeutic Indications

Because these injuries have no immediately severe symptoms, it does not follow that they should be neglected : at the outset one has the power of directing their course by rendering them aseptic, and is able to save the patient much suffering, and to reduce to a minimum the permanent damage that must ensue.

Operation must therefore be practised as early as possible.

Four methods of treatment are open to discussion.

1. **Immobilisation pure and simple.**—This is suitable for wounds caused by long-range bullets. After painting with iodine and applying an aseptic dressing, the hand is placed in a position of slight dorsi-flexion in a palmar plaster splint, extending from the heads of the metacarpal bones to a little above the elbow. Passing the thumb through a hole in the plaster splint is an excellent means of fixing the apparatus and of applying it satisfactorily to the forearm. This splint is kept on for three weeks, when gentle movement is commenced. Complete recovery takes place in one and a half or two months. Sometimes vaso-motor or nerve troubles persist without apparent reason ; they may be considered as a sympathetic neuritis, and treated, as I have elsewhere indicated, by excision

of the cellular sheath of the brachial artery, which is covered with nerve-plexuses.

2. **Esquillectomy.**—In the carpus, where it is always really a partial resection, this operation is suited at the outset to all fractures limited to the carpal bones, whether there be a blind wound or a penetrating one with the wound of exit more or less ragged. It is economical, that is to say it will only affect the bone (semi-lunar or os magnum) or bones directly struck by the missile. If done in the prophylactic stage, there is no need to be afraid of the many recesses of the synovial membrane. When disinfection is done early, the carpus can be considered as composed of one bone only, and if the disinfection has been carefully performed, esquillectomy is practically always sufficient to give a good orthopædic result.

It is the method of choice for all blind wounds of the wrist and the small contused wounds made by grenade splinters, in which serious arthritis of the wrist sets in very rapidly if one does not intervene. In these cases early incision followed by removal of the fractured bone is a matter of great urgency; unless partial resection is performed, total resection will have to be done in a short time, and the functional result of that is quite another matter. When the fracture involves in addition the lower articular ends of the bones of the forearm, a very limited esquillectomy will be done upon them, bearing in mind the usual mildness of septic infection in this region. As much as possible should be preserved, especially the styloid processes, which are always required to prevent future lateral displacement.

When the fracture involves both carpus and metacarpus, as little should be done to the latter bones as possible, especially if the tendons are intact or only slightly damaged. Fractures of the metacarpus generally recover well. The functional result is often better than one expects. If, however, there is much

loss of tendon and therefore no hope of satisfactory restoration of function, less restraint is necessary since the corresponding finger is hopelessly damaged.

But in principle it is best to be extremely conservative in the case of both hand and fingers, since no one can foresee the extent of the eventual recovery of function of a deformed hand.

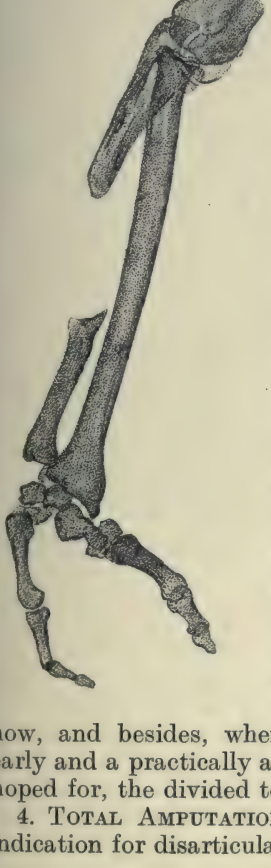

FIG. 50.—A splinter had entered the ulnar side of the forearm, blowing away a portion of the ulna, and had passed through the carpo-metacarpal area, lacerating the tendons of the three middle fingers, and breaking up the corresponding metacarpal bones. Severe sepsis. Esquillectomy of the ulna, disarticulation of three fingers and their metacarpals, and removal of the os magnum have obviated amputation, which appeared necessary.

3. TYPICAL RESECTION.—Naturally this operation is only exceptionally called for. It should be reserved for serious bony injuries, for destruction of the carpus when all the cancellous tissue is crushed: in these cases it is performed without worrying about accompanying lesions of the tendons and muscles, if the vessels and the nerves are intact. The principle is to preserve the hand somehow, and besides, when intervention is done very early and a practically aseptic course can therefore be hoped for, the divided tendons can be sutured.

4. TOTAL AMPUTATION OF THE HAND.—The only indication for disarticulation at the radio-carpal joint,

or amputation through the forearm, is complete crushing of the hand, when the surgeon merely finishes what the missile has begun. Whenever it is possible to preserve even a broken metacarpal bone with its corresponding finger, an atypical ablation of the injured part is preferable to total amputation. Every effort should be made when the thumb is in question. Loss of the hand should be avoided at all costs.

For this purpose limited amputations of one or

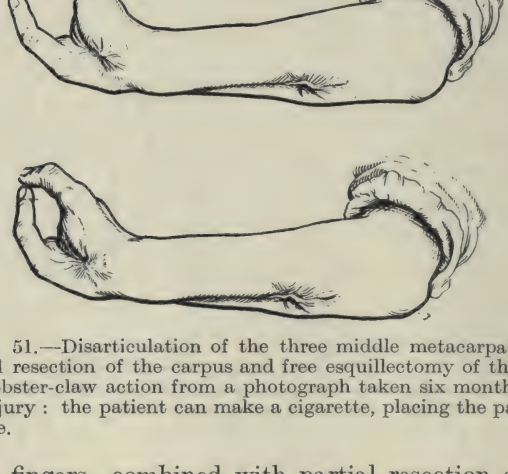

FIG. 51.—Disarticulation of the three middle metacarpals with partial resection of the carpus and free esquillectomy of the ulna. The lobster-claw action from a photograph taken six months after the injury : the patient can make a cigarette, placing the paper on a table.

more fingers, combined with partial resection of the carpal bones, should be freely used. When, for example, an injury to the wrist is accompanied by total destruction of three metacarpals and their tendons, they should be removed with their corresponding carpal bones, leaving only the internal and external supports of the carpus. The lobster's claw thus made will be all the more mobile. Doubtless in these cases it might be possible at times to cause the disappear-

ance of septic phenomena by means of a limited esquillectomy, but recovery is difficult and leaves fingers ankylosed, deformed and immobile, and calling for removal later on. Manifestly the sacrifice of the metacarpal bones should not be lightly made : it is only allowable if there is no hope that their corresponding fingers will ultimately recover their mobility. It will be said, perhaps, that there is always time to intervene later if there is occasion to do so, and that it may then be possible afterwards to limit the operation to removal of the fingers. But as a matter of fact the free drainage provided by ablation of the carpus and metacarpus favours recovery without the formation of septic cavities and without cellulitis of the tendon sheaths, but with perfect use of the other fingers, which is of the utmost importance. On the other hand, whenever one removes two fingers, it is best to remove their metacarpal bones as well, to allow of a better approximation of the remaining digits. Similarly, when one finger is removed, it is best to resect the head of the metacarpal to diminish the interdigital space.

These combined operations are perfectly legitimate and almost always enable one to avoid total amputation of the hand.

Finally, the operation which will be most frequently performed, for the purpose of early disinfection, is that of partial resection, either limited to one or extended to several bones of the carpus, with the addition, if need be, of one or two metacarpals.

III. Operative Technique

As a rule, every operation on the wrist for war-wounds is decidedly atypical. Whatever be the precise technique chosen, two important rules ought to be borne in mind.

The incisions should run as parallel as possible to, and to one side of, the extensor tendons.

The denudation of the bones ought to be done with the rugine, with which the periosteum, the ligaments, and the muscular insertions will be separated. It must be remembered that the life of tendons is precarious since they slough easily : if great care is not used in exposing them, cicatricial contraction and adhesions will jeopardise the result.

(*a*) Access to the Joint.—When a blind wound, or one of limited extent, is concerned, the bone should be reached and exposed by excising the wound of entry, which is practically always dorsal. If the sacrifice of one or more digits appears necessary, it is best to commence the operation by a carpo-metacarpal disarticulation, which freely exposes the depths of the wound.

Fig. 52.—Para-tendinous incisions for resection of the wrist.

If the injuries appear to necessitate merely an extensive resection of the wrist, Ollier's two para-tendinous incisions—the one meta-carpo-radio-dorsal, the other ulno-lateral—should be employed to expose the carpus whenever the wounds permit. The former follows the radial border of the extensor indicis : it extends from the middle of the line joining the two styloid processes as far as the middle third of the second metacarpal bone.

After the tendon has been defined, the incision is carried down to the periosteum and the dorsal ligaments, avoiding the tendon of the extensor carpi

radialis brevior, the insertion of which is hidden by the extensor indicis tendon. The periosteum is incised over the inner edge of the head of the third metacarpal, where the rugine will commence to raise the capsulo-periosteal sheath.

The ulnar incision commences a little above the styloid process of the ulna and runs down to a point 1 in. above the lower end of the fifth metacarpal, nearer its palmar than its dorsal aspect, so as to leave the tendon of the extensor carpi ulnaris in the dorsal margin of the wound. This incision, which crosses a cutaneous branch of the ulnar nerve, which should not be cut, exposes the cuneiform and the unciform bones. It is needless to go over the remaining stages of the operation: they comprise division of the posterior annular ligament to allow retraction of the tendons, denudation of the bone, and extraction of fragments by means of the rugine: they are all easy enough.

Incisions over the outer side of the radius should be avoided as much as possible, because of the presence of the radial artery.

IV. Post-Operative Treatment

1. A CASE OF TOTAL RESECTION OF THE CARPUS will be immobilised in a plaster casing after an aseptic dressing has been applied.

This will be done in the following manner:

Six double thicknesses of tarlatan are cut to make a splint extending from the lower third of the arm to the level of the transverse palmar crease, leaving the fingers free. A prolongation will slightly separate the thumb from the index finger, which is the best method of obviating loss of opposed action later. The splint only covers half the circumference of the limb, which is semi-pronated, with the hand in a position of dorsi-flexion. The hand must be well supported.

At each dressing the splint is removed and the hand carefully kept dorsi-flexed by an assistant. If the plaster has softened, it must be renewed : it is of importance that immobility should be perfect. The

FIG. 53.—Casing for immobilisation of the wrist.

plaster is kept on for several months. The hand has a constant tendency to fall, both on account of its own weight and of the predominance of the flexor over the extensor muscles. At an early date passive and active movements of the fingers will be commenced ; these soon get stiff if they are not moved, and are

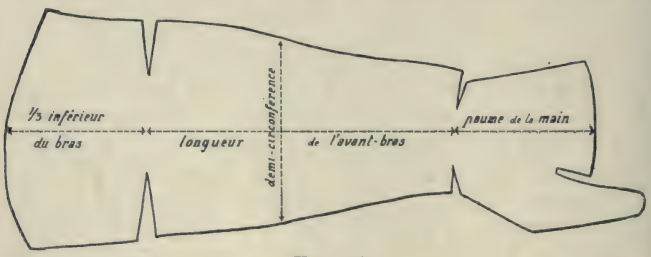

FIG. 54.

then very difficult to restore to their normal mobility. Interrupted plaster splints ought not to be used at the wrist, because they do not leave the fingers sufficient liberty of movement. In fine, one ought never to lose sight of the double object to be attained : fibrous

ankylosis of the wrist in good position, and mobility of the fingers.

2. In Partial Resection it will be quite otherwise. One can and ought to restore free movement to the wrist: the hand has no tendency to fall or to deviate from its proper position. At an early period exercises ought to be commenced, so as to produce a supple carpal joint. If all local and constitutional symptoms of sepsis have disappeared, they will be undertaken as early as the eighth day, and should be progressive and gentle, first passive, and later active. There is no need for hurry: it is a question of patience, not speed.

In the intervals between the movements the limb is replaced in the plaster splint, which will not be finally discarded until after a fortnight or three weeks.

3. In Partial Carpo-metacarpal Amputation it will be well to employ hypertonic saline solution as a dressing for a week. When the wound is not perfectly aseptic, a little arthritis develops round the carpus: this is shown by an œdematous swelling of the hand, which a dry dressing does not easily subdue. The osmotic currents produced by the concentrated saline solution hinder absorption in the many synovial sacs exposed and favour the cure.

This moist saline dressing does not permit the limb to be retained in the plaster casing. During this period, therefore, the hand is supported in a position of slight dorsal flexion upon a wide wooden splint, the hand part being firmly padded with sterilised cotton wool. The splint ought to extend up as far as the upper third of the forearm to make the patient comfortable.

After eight to ten days of these moist saline dressings, which are renewed daily or every second day, according to the temperature chart, the ordinary dry aseptic dressing is reverted to. At an early date,

mobilisation of the fingers and phalanges will be considered.

V. Evacuation of Patients with Wrist Wounds

No one wounded in the wrist should be evacuated without primary operation except he be a case of bullet wound with punctiform openings. All should be operated upon with the least possible delay, as has been indicated above.

At the end of forty-eight hours, if the operation has been sufficiently radical and all is going well, a patient who has undergone partial resection can be sent out without risk; if he has had total resection done, eight days ought to be allowed; and the same period, or a little less, if partial amputation has been performed and the result appears favourable.

The limb should be immobilised in a plaster apparatus, made as described above, viz. a palmar splint extending from the flexure of the fingers to above the elbow, the hand being slightly dorsi-flexed. The plaster should be removed and reapplied on arrival. The journey should not exceed twenty-four hours.

VI. Treatment of Patients seen late or after Evacuation

1. When a Patient, who has been operated upon early, arrives in good condition.—He has undergone a primary resection, partial or total, of the carpus, and he ought to recover rapidly with movement of the joint (in case of local removal of bone), or with ankylosis, if the after-treatment is suitably supervised, as has been set out above.

2. A Patient, who has not been operated upon, or has been insufficiently incised, arrives with Arthritis of the Wrist.—This arthritis practically always involves the whole joint. Normally, the wrist-joint possesses many distinct and independent synovial

membranes, but they have many contiguous diverticula, they are in immediate contact, and there are often minute channels of communication between them. As soon as one of these is opened and becomes infected, the different articulations are rapidly attacked, as if there were but one synovial membrane and one articulation. On the other hand, if a missile traversing one of the bones has been stopped, as it often is, at the palmar surface in contact with the synovial sheaths, there is almost always a deep abscess there and this can only be opened and drained by extensive resection. This is not the time for limited arthrotomies and economical resections. Partial resection is as valuable as a primary operation as it is detestable as a secondary measure. Complete removal of the carpus should be effected at once; it is impossible to remove a single bone without opening the neighbouring serous membranes, and, if they are invaded, intervention has only served to spread the mischief.

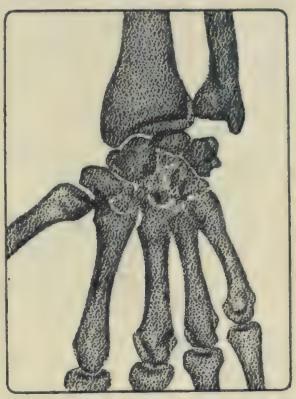

FIG. 55.—Secondary arthritis of the wrist after a blind wound caused by shell-splinter. The patient, retained in a hospital at the front for a wound of the skull, was evacuated on the twelfth day with a small dorsal wound of the wrist apparently doing well. The radiograph taken on the fifteenth day showed a small projectile and a blurred appearance of all the metacarpal bones; the wrist was rather swollen and painful, the patient slightly febrile.

On the other hand, if one delays, the synovial sheaths of the flexors are attacked; purulent foci are formed in the forearm, the constitutional symptoms become worse, and the function of the hand is definitely endangered. Certain parts of the carpal bones, viz. the

unciform process and the tubercle of the scaphoid which constitute the lateral boundaries of the palmar carpal groove, have their periosteum intimately blended with the synovial membranes of the flexor sheaths; their infection must be prevented at any cost, and to ensure this, total resection of the carpus should be done without delay; besides, it gives excellent results and avoids secondary amputations.

FIG. 56.—The same case as fig. 55. Exploration showed that the splinter had passed through the os magnum and was embedded in the palmar ligaments. The bones of the carpus had all lost their cartilaginous covering, except the upper part of the scaphoid and the semilunar. There was a large palmar abscess spreading along the sheaths towards the forearm. The rather unusual aspect of the plate is due to the position of dorsal flexion in which the hand was immobilised. Radiograph taken three days after operation, which gave a good result.

But the situation may be more complicated: when a splintered carpo-metacarpal fracture exists and has not been sufficiently cleared out and there are signs of severe general infection, any fresh interference provokes an acute attack of general arthritis of an extremely violent type, accompanied by formidable general and local symptoms, which seems to demand amputation. There is, in short, a dangerous period in secondary intervention for injuries of the wrist. Does this mean that at this stage it is a question of doing nothing or of amputating? Not at all. The post-operative complications are owing to the fact that surgical interference roughly opens up the joints in

the vicinity of the one primarily affected and infects them.

In order to prevent operation from being followed by bad symptoms, and in order to avoid this acute arthritis, it is necessary immediately to expose the carpus in the neighbourhood of the injury and either remove it or the broken metacarpal bones and the damaged tendons. By laying the cavity widely open and combining partial resection of the carpus with amputation of the metacarpals and fingers which have been injured, the sepsis is limited and a hand, though a poor one, is saved.

To sum up, these cases are not to be treated by esquillectomy or by local operations, but by combined amputation and resection, followed by dressing with a hypertonic salt solution and by satisfactory immobilisation.

3. When a Patient is seen late with persistent Suppuration.—If there is an obstinate sinus, limited resection by means of the rugine is indicated.

If some of the fingers are deformed or drawn out of position and useless, appropriate disarticulation can be done.

Troublesome tendinous adhesions are remediable by the interposition of fatty grafts between the cicatrices and the tendons. I have obtained excellent results by these means.

CHAPTER V

WOUNDS AND FRACTURES OF THE HIP

I. Anatomical Types and Clinical Course

WOUNDS of the hip-joint appear rare when we consider the frequency of joint wounds in general. This is not due to the lucky escape of this deeply seated joint but rather to the extreme gravity of the wounds, a great number of which are accompanied by fracture of the pelvis, injury of the bladder, and perforation of the intestine, and rapid death is the usual result. Besides, bullet wounds with explosive effects produce in the massive muscular covering of the hip such formidable damage, and such destruction of vessels and nerves, that immediate death from shock and loss of blood is very common. In this way many wounds of the hip-joint escape observation, and the number is reduced to those one is called upon to treat.

In practice the following types must be distinguished :

(*a*) *A Bullet Wound with punctiform skin-openings.*— The bullet perforates the neck or the head of the bone under most variable circumstanes, producing perhaps a limited injury (furrow, perforation, erosion), or perhaps bony damage which, though considerable, may yet run an aseptic course. Usually voluminous callus is formed and there is ankylosis of the hip.

(*b*) *Cancellous crushing, with a retained missile.*— This is the starting-point of progressive osteitis : according to its position, in the neck or the head of

the bone, articular osteitis is more or less early in appearing. But as a general rule, an acute suppurative arthritis is developed, which may lead to a rapidly fatal result if immediate intervention is not undertaken, or to a less acute form of the disease which leads to ankylosis after pretty severe suppuration.

(*c*) *Separation of the head of the femur.*—This is a

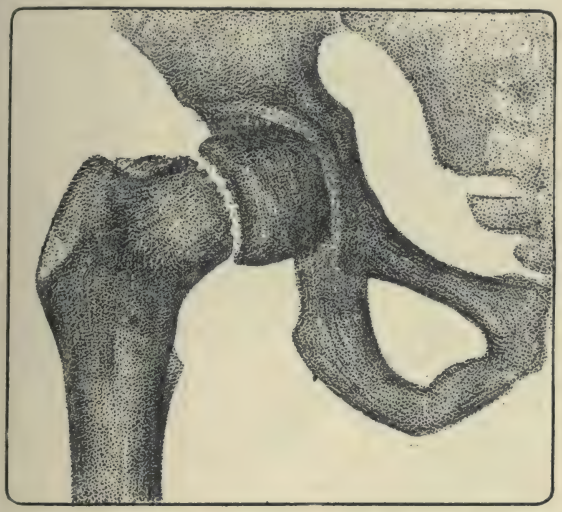

Fig. 57.—Separation of the head of the femur by a shell-splinter with a postero-anterior wound. Primary resection by anterior incision. Recovery.

frequent injury arising from shell-splinters coming from a height. At first the trouble may appear slight, but towards the third or fourth day an acute arthritis develops, with septicæmia and suppuration of the neighbouring muscles of a sloughing type. The head of the bone forms a deep-seated sequestrum, and if it is not removed without delay death pretty certainly supervenes.

(*d*) *Transverse fracture through the trochanters.*—The projectile entering at the great trochanter finds its way towards the lesser one, above or below it, without, as a rule, interrupting the continuity of the shaft. But the violence of the injury has an extremely severe effect within the joint, which it is always important to recognise and look out for; a fracture of the neck is caused by contre-coup. In consequence of the infection produced by the passage of the missile, there is rapid development of a gangrenous articular osteitis of a very grave type which is almost always fatal.

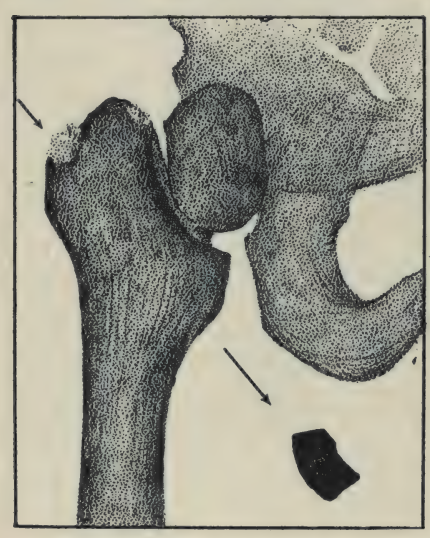

Fig. 58.—Fracture of the neck by contre-coup, the wound passing through the trochanter. The separation of the head of the humerus was not recognised in the absence of radiography. Later resection of the head did not prevent the death of the patient by sepsis. Early resection would have been followed by recovery.

(*e*) *Smashing of the hip.*—This is seen sometimes in large wounds of the outer side of the thigh and the buttocks which do not involve the femoral vessels and sciatic nerve. The wounded, who are always under the influence of extreme shock, may survive, but quite exceptionally. The enormous damaged area of which the joint is the centre is ready to become infected, and, unless rapid intervention is undertaken,

an acute gangrenous septicæmia rapidly carries off the patient.

Each of these fractures, whatever the type, may be single, but more frequently fissures of the acetabulum or of the iliac bone accompany them. At other times they are associated with visceral lesions, vesical fistulæ, or ruptures of the colon. These are grave complications which make it all the more urgent to practise an intervention capable of enabling the osteo-articular injury to run an aseptic course. In all these cases the prognosis should be very guarded.

II. Primary Therapeutic Indications

It is well to put on one side, as usual, those cases of bullet wounds with very narrow cutaneous openings, the treatment of which is identical with that of simple fractures; that is to say, immediate immobilisation in a plaster casing extending from the back of the pelvis to below the knee, or in a plaster spica enclosing the whole lower limb, which is fixed in a position of extension and abduction. The extension should be kept up while the plaster is being applied, unless it is going to be applied secondarily. The patient recovers with ankylosis and often with marked shortening. It is unusual for the seat of fracture to be infected primarily, but an obstinate sinus is not an unusual after-development: I have seen several examples of it. Barring these cases, which are becoming less and less frequent in trench-warfare, all other wounds of the hip and all those caused by splinters of shell or grenades ought to be operated upon at once, because from the first they are all in imminent danger of severe infection. Owing to the depth of the joint and the difficulty of reaching it, one is doubtless tempted to immobilise the limb and wait for symptoms of the onset of infection before doing anything further. But this is a deplorable course to take: at the hip, the necessity of operative

measures which are prophylactic against infection is as pressing as anywhere else, if not more so. If the patient is suffering from shock, he must be treated by means of the usual stimulants (oil and camphor, artificial serum)—morphine is very useful in severe cases of shock—and then early operation must be undertaken without waiting for the clinical signs of established septic poisoning.

Three operations have their indications and must be considered.

1. **Limited Esquillectomy and Drainage.**—Theoretically this operation is suited to partial lesions, to some degree extra-articular, as for instance certain marginal fractures of the great trochanter. But the frequency of fracture by contre-coup of the head or the neck limits the employment of it in practice. One should never admit *a priori* that a fracture of the trochanter is the only one, until radioscopy has proved that it is so, and unless it is a case of incomplete cancellous crushing caused by a missile which remains *in situ.*

Simple esquillectomy is scarcely ever indicated for injuries which are properly speaking articular. Indeed, at the hip it is very rare to see partial and limited injuries; in consequence of the anatomical conformation of the upper extremity of the femur, one sees hardly any but complete fractures such as those of the neck and head, and, for my own part, I have never met with any others. Hence it can be seen that, the joint being a very close-fitting one, arthrotomy is an illusory operation, and it is only by wilfully deceiving one's self, that one can hope for anything from it.

The objection has been raised that patients have recovered after drainage through the buttock or thigh; but to begin with, *were they cases of articular lesions?* The mistake is so easy. Let us admit that some recover, as anyone can see for himself. But these are only fortunate exceptions: under the big muscles covering the hip-joint, simple drainage cannot suffice

to cure a deep-seated osteitis, which elsewhere requires resection. It is certain that the patients who have died or have suffered from obstinate sinuses are much more numerous.

It is said, too, that it is difficult to do anything else, and that simple drainage round the joint will always remain the method in general use. But I cannot think that this is founded upon precise anatomical and clinical data : this treatment by drainage is not adopted because of the good results it gives, but by reason of timidity in operating, and of a general want of precision in diagnosis. One fact dominates the situation : the mortality from sepsis is considerable among those who have escaped death from shock or hæmorrhage, and operations for drainage without free removal of bone do little to diminish this secondary mortality. Logically it cannot be otherwise. There is no reason why a joint so deeply situated should not follow the usual course of wounds of joints, and it should be admitted as a principle that, except in very rare cases, justified by radiography, a blind esquillectomy cannot constitute a sufficient method of treatment for wounds of the hip-joint.

2. **Resection.**—It is quite different with resection, which, while it removes the head of the femur, gets rid of the principal lesion, and freely exposes the seat of injury : under these circumstances no infection ensues, and the wound progresses without complications, like all war-wounds which are treated logically and in time. Resection has the further advantage of permitting direct treatment of the rim of the acetabulum, or the bottom of its cavity.

The only objection that can be urged against it is the poorness of its orthopædic results. When, in order to remove the head which has been separated from the neck, or to saw through the neck in front of the trochanters, a free denudation of these latter is

carried out, the insertions of the muscles into the trochanter are more or less disorganised, the external attachments of the capsule are destroyed, and the upper extremity of the femur is gradually dislocated upwards and backwards on to the ilium. If to this is added the loss of power resulting from the damage done to the muscles and nerves of the buttock it is easily understood that the result, so far as the function of the joint is concerned, leaves much to be desired.

It is true that the wounded survive, and that is a consideration. But there is more than this to be said: the functional result after resection can be much improved by making an anterior incision leading straight on to the neck and head of the bone, which allows resection of both with a minimum of damage. Under these circumstances, the orthopædic result is excellent, and resection becomes an operation at once conservative, beneficent, and useful. Resection should be employed at once then for all fractures of the head and neck caused by splinters of shell and grenade, or by a bullet fired at short range.

3. **Disarticulation.**—When there is considerable damage of the explosive type, when the fracture involves both shaft and epiphysis, when the upper third of the femur is reduced to fragments, early disarticulation, immediately the shock has passed off, or has sufficiently abated, is indicated as the only chance of saving life.

To sum up, primary resection by an anterior incision applies to almost all the fractures of the head and neck which do not cause immediate death, and to all those in which preservation of the limb ought to be attempted. The others are amenable only to disarticulation.

III. Operative Technique

1. Resection.—Resection should be performed in as typical a manner as possible; the orifices of entry

and exit, without exception, ought only to be used as means of drainage, not as means of access. Classically, the most direct incision to the hip is the postero-external one; most often it traverses the whole length of the gluteus maximus, crosses the medius and minimus, and finally, after opening the capsule, severs the tendinous attachments of the glutei muscles and those between the trochanter and the pelvis. This method has the great advantage of draining at the lowest point, but the orthopædic result is only moderate. There is no ankylosis, and the femur slides over the iliac bone in a position of marked adduction.

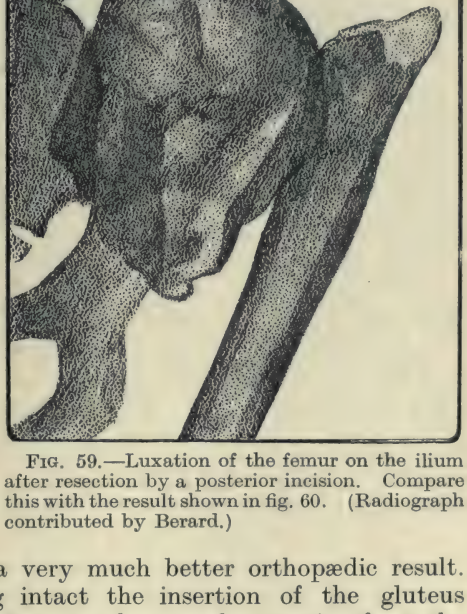

FIG. 59.—Luxation of the femur on the ilium after resection by a posterior incision. Compare this with the result shown in fig. 60. (Radiograph contributed by Berard.)

The anterior incision, which exposes the joint without sacrificing any muscles or nerves, gives a very much better orthopædic result. By preserving intact the insertion of the gluteus medius and minimus, the muscles passing from the pelvis to the trochanter and the most important part of the capsule, it favours ankylosis and consequently ensures a satisfactory result. It is, moreover, easier

to perform and does not inflict any severe operative damage; on this ground it is specially indicated as the primary operation of choice. To realise its advantages the technique advised by Berard, and used by him with excellent functional results, should be employed.

In this method the anterior incision follows the long axis of the head and neck, starting from the anterior inferior iliac spine to end a little below

FIG. 60.—Resection of the hip by anterior incision. (Radiograph of a case operated upon by Berard.)

the top of the trochanter. It thus opens up the space between the tensor vaginæ femoris and the gluteus minimus on the outside, and the external border of the sartorius and the psoas on the inside. The muscles are well retracted, the thigh is semi-flexed and slightly abducted, and the capsule incised along its whole length. Each edge of the incision in the latter is held by forceps and divided transversely at the level of the brim of the acetabulum, and this releases the

circumference of the head. It is then easy to remove the fractured parts. Then posterior drainage is established by the aid of a pair of forceps introduced into the wound and made to protrude in the buttock, where they seize a drainage tube. The edges of the wound of entry are then trimmed with as much care as if resection had not been done; the sloughing muscular tissue is excised, the missile is removed, and, if necessary, the trochanter is carefully curetted. Then the operation wound is closed. The idea dominating all this detail is to put the wounds caused by the operation and the injury into such a condition that they may run an aseptic course.

2. Disarticulation.—The patients whose wounds call for this form of treatment always arrive in a state of extreme shock. The indication is that intervention should only be undertaken after an interval for rest and recovery. The operation should be the simplest and least violent; that is to say, one should commence by amputating the thigh, straight through its upper third after ligaturing the femoral vessels at the level of the section; then a free incision is made from a little above the trochanter down to the circular incision. This gives two large muscular flaps out of which the injured femur can be easily and rapidly removed.

This cavity is left wide open without sutures, and dressings are applied flat to its surface. Immediate intra-venous injection of artificial serum in large doses (1 to 1½ litres) will complete an operation, which, if performed without delay, will save the lives of some who would die if rapid action were not taken.

IV. Post-Operative Treatment

We shall only deal with the treatment after resection.

(a) *Dressing and Immobilisation.*—The wound is packed with aseptic gauze and a large spica bandage

applied, with wool over the posterior part. In order to do this dressing without disturbing the resected joint and while keeping the limb in good position, three supports should be placed beneath the patient, one under the head, another in the middle of the back, and the third under the buttocks. Another apparatus, resembling what Ollier describes as his "pelvi-cervico support," may be preferred. For this three simple padded rests are used: the cervical support is hollowed out and is a little higher than the others. They are all three arranged on a board, the two upper ones being moveable and the lower one

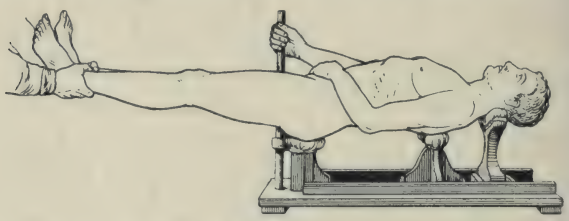

FIG. 61.—Ollier's improvised pelvi-cervical support.

being made fast. To this latter a solid vertical metal rod is fixed which lies between the patient's legs so as to prevent the body from being pulled down when traction is made upon the limb.

The patient is placed upon the support, and the lower limbs are held in a position of abduction by an assistant. The hip is immobilised by means of a T-shaped plaster splint, the horizontal limbs of which surround two-thirds of the circumference of the pelvis, and the vertical, longer portion is moulded to the anterior surface of the limb. Those who are not accustomed to this plaster casing will very likely not look kindly upon it at first sight. It will appear paradoxical. Yet in reality it immobilises very well. The patients like it, and the dressings are much

facilitated. It is very strong, and will serve for a long time; and, finally, it offers the advantage of facilitating the application of continuous extension.

This plaster apparatus is made of eight double thick-

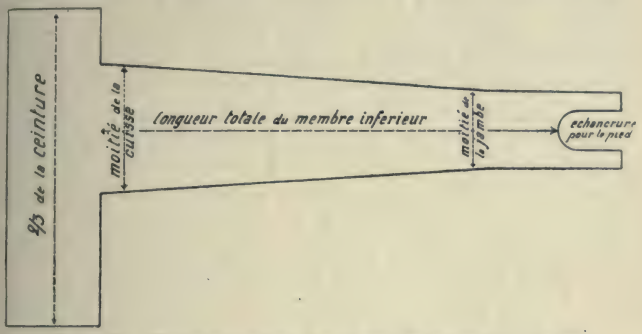

FIG. 62.—T-shaped splint for dorsal pelvi-pedial casing.

nesses of tarlatan in this way: It is T-shaped with unequal horizontal branches. The long vertical branch will be half the circumference of the limb in width, and is cut out at the lower end into a U-shape, the two sides

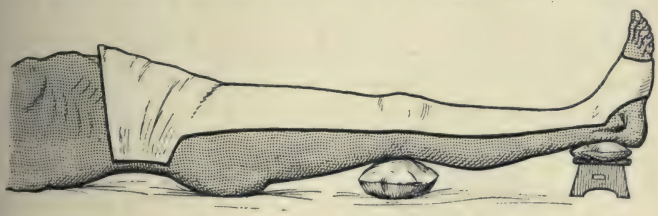

FIG. 63.—Dorsal pelvi-pedial casing for resection of the hip-joint. A bandage fixes the casing firmly to the lower limb and completely immobilises the hip. Continuous extension is possible.

of which are intended to go round the foot. The wide horizontal branch will be a little deeper than the height of the pelvis and will be long enough to go round two-thirds of the pelvic circumference.

Before putting on the plaster, some wool should be placed over the epigastrium, so as not to compress the abdomen, and a gauze bandage is applied to the limb as far as the foot. The apparatus may be made in two pieces, the pelvic portion widely covering and holding in position the crural portion, or, better still, the two parts may be sewn together. The bandage is impregnated with plaster and is moulded to the limb by a few turns of an ordinary bandage, and care is taken to keep the limb in the desired position during the eight or ten minutes that it takes to dry. The patient is put afterwards on a bed, the mattress of which rests on fracture boards. Thanks to this precaution and the use of an air pillow under the buttocks, Bonnet's splint can be dispensed with.

(b) *Later Dressings.*—It is often necessary to renew the dressing the day after the operation, or in the following forty-eight hours. Anæsthesia by chloride of ethyl will facilitate matters greatly. The plaster is reapplied without difficulty. The plugging in the anterior wound need only be changed at the end of five or six days, even later if possible. The posterior drainage tube, if all goes well, should be replaced by a smaller one at the end of twelve days. If the temperature rises, attempts should be made, under anæsthesia if necessary, to see if there are any pockets of pus posteriorly, or retention of discharges within the acetabulum.

If the temperature is raised and drainage appears to be unsatisfactory, continuous extension is indicated. For that purpose, before replacing the plaster, strips of adhesive strapping are applied to the thigh in the form of a stirrup, according to Tillaux's classical extension method. The plaster is then fitted over the limb and traction applied in the ordinary way. If the wound progresses aseptically, few dressings are needed. A cure will be obtained in about two months. It is beneficial to maintain immobilisation

in the abducted position for three months at least; walking will only be permitted when the patient wears a plaster splint surrounding the lower limb. At the end of six months the patient may walk with a raised boot and a stick.

V. Evacuation of Patients with Hip Wounds

Patients wounded in the hip-joint cannot be moved at first. Those injured by a long-range bullet ought to be kept under observation for a week. At the end of that time they can be evacuated in a plaster splint embracing the lower limb and the pelvis, the wounded thigh being abducted to 25°, and the plaster spica being put on under traction (16 to 21 lb.). The "pelvi-pedial" splint, described above, can also be used. All other cases of wounds of the hip are only to be evacuated after a primary prophylactic operation. They should be kept as long as possible in the front ambulances, evacuated only by short stages, and after a sojourn of at least fifteen days on the spot. The ideal method is to keep them till they are quite well.

The splint for transport which is best for them is the "pelvi-pedial" splint described above. If it is available, the patient is put into a Bonnet's splint, which will make the journey easier. But this journey ought to be as short as possible, and the patient should be set down at the first surgical station (*relai*).

VI. Treatment of Patients seen late or after Evacuation

1. A Wounded man, picked up some time after being injured, arrives at the Ambulance at the end of 24 or 48 hours.—Such cases are frequent; wounds of the hip are profoundly shocked, are generally incapable of being moved early, and their trans-

port is always difficult, especially in the narrow, winding trenches. Under these conditions the articular wound is practically always infected, and resection of the hip must be performed at once.

The treatment is commenced by cleaning up the wounds of entrance and exit so that any foreign bodies can be removed, and an exact idea gained of the extent of the injuries. One would not be content to diagnose a simple fracture of the trochanter if the wound ran along the inter-trochanteric line. It would always be necessary to remember the possibility of there being separation of the head of the bone by contre-coup, and if radiography is not available, one would try to ascertain the exact condition by clinical examination and surgical exploration.

I lost a patient last year through not having done this: secondary resection was too late to arrest sepsis. On the other hand, I cured by resection a man wounded in the buttock, the head of whose femur had been separated by a bullet which had passed through the trochanter.

After the wounds have been explored and cleared out, the anterior incision should be made, and resection performed according to the technique indicated above. If the neck be found incompletely fractured, it is not necessary to confine oneself to esquillectomy, but typical intra-cervical, pre-trochanteric resection should be done.

Immobilisation should be effected by means of the plaster casing already described and evacuation delayed as long as possible.

2. A WOUNDED MAN ARRIVES AT THE BASE, UNOPERATED UPON, BUT DOING WELL.—This is quite an exceptional occurrence. The missile, which is not markedly septic, usually remains in contact with the head of the bone, which may or may not be fractured. Early intervention is not called for, although the removal of a foreign body is always necessary; the

treatment should be commenced by strict immobilisation for some days. If all goes well, the projectile should be removed at leisure under radioscopy or after precise localisation. Under these circumstances operations on the bone can sometimes be avoided, leaving ankylosis to ensue naturally. If there is any fever, intervention should be undertaken without delay and according to the ascertained nature of the injury.

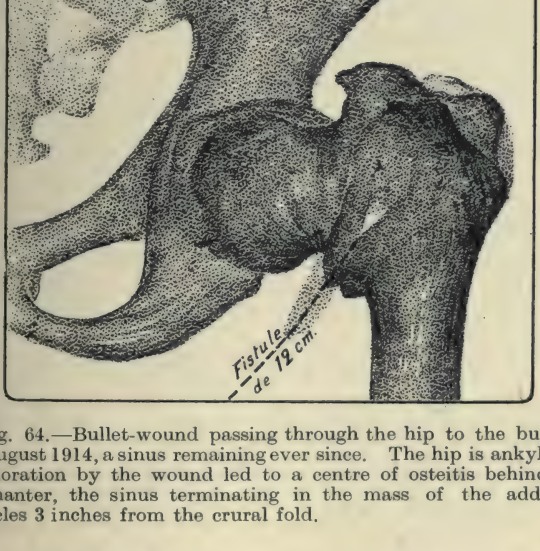

Fig. 64.—Bullet-wound passing through the hip to the buttock in August 1914, a sinus remaining ever since. The hip is ankylosed. Exploration by the wound led to a centre of osteitis behind the trochanter, the sinus terminating in the mass of the adductor muscles 3 inches from the crural fold.

It should be limited to simple drainage after removal of the missile, or resection; the latter is often preferable.

3. A WOUNDED MAN, UNOPERATED UPON, HAS A SUPPURATIVE ARTHRITIS.—Even if there are accompanying visceral injuries (vesical or fæcal fistula), resection of the hip should be performed at once by

the anterior method, the joint lesions being much more important than the visceral wound from the point of view of life. In these cases one will generally find it advisable to apply continuous extension directly after the operation ; it greatly facilitates drainage of the joint.

4. A Wounded man is seen after some delay with a faulty Ankylosis or Sinuses.—(*a*) *When there are one or more sinuses at the hip.*—After radioscopic examination, either a simple curettage or resection will be performed, according to the injury present. There is some advantage in a partial operation like curettage, in not following the fistula but going directly for the bony focus which keeps it up. The sinuses are often very long, and to follow them accurately considerable damage must be done. Instead of this, it will be better to make directly for the point indicated by the radiograph, or by exploration with the probe. In a case of this kind, where a sinus four and a half inches long existed on the internal surface of the thigh in the middle of the adductor muscles, I was able, by making an incision near the trochanter, to come straight upon a centre of osteitis in the neck of the femur.

(*b*) *When the limb is ankylosed in a bad position*, i.e. flexion and adduction, sub-trochanteric osteotomy should be performed at a distance from the seat of the old injury, but not resection.

CHAPTER VI

WOUNDS AND FRACTURES OF THE KNEE

I. Anatomical Types and Clinical Course

PENETRATING wounds of the knee are articular lesions which during the present war have given surgeons the greatest anxiety and have caused them the greatest disappointment. The surprising rapidity with which sepsis, often fatal, develops, and the impossibility of checking it by repeated operations, each being too late, have produced in the mind of the surgeons at the front a profound pessimism ; many have arrived at the conclusion that amputation should be performed at the first appearance of infection, without waiting for arthrotomy or resection—an opinion which is in marked contrast with the optimism of certain surgeons at the base.

Strictly speaking, this pessimism is not justified ; conservative surgery is perfectly suited to the knee-joint, but there is no part of the body where it is more important to choose straight away the right operation suited to any given case. Each operation has very precise indications ; it is of great importance to do only the operation required and to do it early. These indications are based upon an exact knowledge of the several anatomical types of injury, which are as follows :

(*a*) A PUNCTURED WOUND WITH PUNCTIFORM SKIN-OPENINGS.—This is really a puncture of the synovial membrane, accompanied or not by a fracture, generally not comminuted, but always followed by hæmarthrosis.

In spite of the local pyrexia of the first few days and the increase in the size of the knee, these wounds heal readily if the limb is rigidly immobilised, and the knee regains almost normal action after two or three months, except in the case of severe fractures, which lead to ankylosis, or at least to a considerable limitation of movement. Out of 38 cases that I have collected (10 my own, 19 of Gayet, 2 of Delore, 7 of Cotte), I have counted 38 recoveries.

(*b*) SMALL OR MODERATE-SIZED WOUNDS WITH PARIETAL FRACTURE OF THE KNEE AND THE MISSILE IN SITU.—These are the most frequent cases. The wound is very small in appearance; its edges are lacerated and contused; pressure sometimes causes the exudation of viscid blood-stained fluid with small blackish clots. On arrival at the ambulance the injury may appear trifling. An ordinary hæmarthrosis may be diagnosed, and the existence of penetration of the joint only suspected from the distension of the synovial membrane, which is not a diagnostic sign, and has no absolute importance, because foreign bodies in contact with it, but outside the joint, often give rise to a voluminous hæmarthrosis.* If one rests satisfied with that opinion, on the second day symptoms of sepsis appear and generally develop rapidly, until death occurs after a short interval.

This dangerous condition is due: (1) to the presence in the joint of septic particles of clothing, earth, chalk, etc., causing acute arthritis; (2) to the existence of fissures more or less prolonged into the shafts of the femur or tibia, whence arises a formidable osteomyelitis. Unless there is intervention, death ensues in two-thirds of the cases from gas gangrene, or some-

* These are the cases that lead certain surgeons to believe that a number of wounds of the knee caused by shell-fragments can be cured by immobilisation, aspiration, or the application of ice. These non-penetrating wounds of the knee are like non-penetrating wounds of the abdomen, and they should not be taken into account in speaking of the real gravity of wounds of joints.

times from articular septicæmia. Generally the symptoms of sepsis force us to act, and the following is the course of events : After two days of immobilisation in a splint, the patient being feverish and in a poor general condition, arthrotomy is performed to drain the joint. The septic condition continues, and two days later fresh drainage tubes are inserted alongside those already inserted. Sometimes an incision is made in the popliteal space to obtain better drainage, but that does not stop the infection ; the face becomes livid, the patient looks ill, and the general condition is profoundly affected. A resection is then performed, while the temperature is still high, but it is followed by no remission of the symptoms : pockets of pus form at the back of the thigh and leg and phlebitis may occur. Amputation is finally decided upon, but it is too late, and the patient dies soon after. The whole course of the case has occupied a fortnight or three weeks. Here is a typical example that I came across in a patient treated at the front and arriving in my wards in a pretty bad state.

C. J. was wounded on April 8th by a shell-splinter in the right leg and knee and the left leg. On the right side there was a fracture of the tibia. Intervention was not considered necessary, the patient being in a state of shock, and the two lower limbs were immobilised and antiseptic dressings applied. Four days later, on account of severe symptoms of infection, the fracture of the right leg was explored ; fragments were removed, a solution of iodoform in ether was injected into the wound, and the knee explored. The wound did not appear to communicate with the joint ; the hæmarthrosis was relieved by puncture and the limb immobilised in a plaster casing. In the left leg there was an infected fracture of the fibula and some sloughing muscular tissue, to which the general symptoms were attributed ; the limb was amputated at the seat of election. In spite of this the general

condition remained grave, the temperature reached 39·6° C. (103° F.), and, on the 17th, arthrotomy of the right knee was performed and a quantity of pus let out. On the 21st, the temperature being 40° C. (104° F.) and the pulse 130, the right thigh was amputated. On examination of the limb (as the medical case sheet which accompanies the patient says), a purulent arthritis is found with wads of clothing, a wound of the external condyle, and a fissure of the tibia extending right through the head. Then the patient was evacuated to the base three weeks after his injuries, his general condition being fair: it is certain that early intervention would have avoided the double amputation.

At other times, in an apparently favourable case, death occurs from chronic septicæmia, taking about two months; at the autopsy, abscesses are found at the back of the leg and thigh communicating with the joint, and there are miliary abscesses in the lungs, kidneys, liver, and spleen. At the outbreak of the war these cases were so frequent that for many surgeons there was only one treatment for injuries of the knee—amputation of the thigh at the first sign of sepsis.

It was on this account that, in June 1915, Tuffier wrote that he was appalled at the number of amputations of the thigh consequent upon injuries of the knee. From what I have seen at medical boards, two-thirds, if not more, of the amputations in the thigh have been done for wounds of the knee. Must it be said, then, that these wounds are beyond the resources of surgery? Most certainly not! Wounds of the knee only take this lamentable course if the decision to operate is not taken promptly; the majority of those that are suitably operated upon in time, run a perfectly simple course; but to operate successfully it is necessary to recognise that, independently of the muscular and synovial injury, there are often superficial cracks, crush-fractures or fissures in the bones,

and that a missile and the fragments of clothing in contact with it may cause these fractures to become gravely complicated. However mild the appearance may be at the outset, if a missile has penetrated the joint, there is every reason for the gravest apprehension.

(*c*) Fractures of the Femur, Tibia, or Patella.—In these cases the projectile, shell- or bomb-splinter, penetrates a condyle without fissuring the bone (a frequent type), crushes the cancellous tissue of the tibia, or smashes the patella. Sometimes, but less often, a double fracture of the femur and tibia, or a T-shaped fracture of the femur, is found. In other cases a short-range bullet has smashed the whole or part of the articular ends. There are rarely many bony fragments, at least in my experience, while fissures radiating down the shaft are frequently found.

The occurrence of acute septic infection is more constant and more formidable in these cases than in the preceding ones. If the patient is not carried off by acute septicæmia, he is liable to suppurative arthritis, to deep, diffuse cellulitis of the thigh, and to secondary hæmorrhage from the popliteal. In short, if intervention is not practised at once, amputation soon becomes necessary, and only too often it is unable to save the patient's life.

(*d*) Destruction of the Knee.—In a number of cases, not only are the articular extremities completely crushed, but there is also considerable damage to the shaft of the bone, and fissures extend far down the length of the femur or the tibia. In these cases the vessels and nerves are usually damaged ; infection occurs early in the necrosed tissues, and in the course of the first twenty-four hours gangrene develops with the formation of gas and fœtid sloughs, if not true gas gangrene. There is immediate and considerable shock, which does not pass off ; the mucous membranes

are pale, the pulse becomes thready, the breathing superficial, and the skin cold and clammy.

In short, apart from the first type of injuries, wounds of the knee are of extreme gravity if they are left untreated in the first few hours. If one waits for the indications of sepsis before coming to a decision, one is always a day or an operation behind-hand. It is necessary to act at once, and to be beforehand with whatever may be happening.

II. Primary Therapeutic Indications

There are four methods of treatment, each with its own indications :

1. **Immobilisation, with or without Aspiration.**— Rigid immobilisation of the knee, with aspiration if there is abundant hæmarthrosis, is suitable for bullet wounds with punctiform openings, but for these only. Doubtless cases of shell-splinter wounds could be cited in which this simple treatment has been sufficient to obtain a cure, but these are, and can only be, exceptions. Besides, among the cases reported are some which are really only parietal, non-penetrating wounds ; and in many others secondary removal of the missile has become ultimately necessary. Simple immobilisation then should be reserved for long-range bullet-wounds.

After careful examination, if it is a case of bullet-wound, and if the skin wounds are both very inconsiderable, an aseptic dressing should be applied with pressure, without operation, and a posterior plaster splint applied from the middle of the thigh to the end of the foot. If the effusion is abundant and painful, the synovial membrane may be punctured if time can be spared, for it is not absolutely necessary ; in any case, it should be a simple aspiration. It is needless to inject ether or any other antiseptic into the joint, and as a rule there is no occasion to repeat the puncture.

Rest will suffice to bring about a cure.

2. **Arthrotomy.**—There are all sorts of methods of arthrotomy of the knee.

The classical operation is done by two incisions near the patella, which are often made too small, through which one or two drainage tubes are passed crosswise, above, below, or behind the patella.

Ollier's arthrotomy, which is little known outside the Lyons school, comprises four and sometimes even five incisions, two antero-lateral, each about four inches long, one on each side of the patella, extending high and low enough to drain the anterior cul-de-sac above and below the patella ; and two postero-lateral incisions, 1½ in. long, passing, one in front of the tendon of the biceps, and the other between the inner hamstrings. The attachments of the lateral ligaments are divided to the requisite degree, and then between the two incisions on the same side a drainage tube is passed into the joint and under the synovial membrane, but not between the bones. If necessary, a fifth, posterior, incision is made in the popliteal space between the condyles.

Jaboulay's arthrotomy is a simple incision of the supra-patellar pouch : the foot is raised considerably, so that drainage of the synovial cavity is made from its lowest point.

Anterior transverse arthrotomy.—This was described by Ollier but little employed before the present war. In it the knee is widely opened by means of a curved incision, convex downwards, cutting through the ligamentum patellæ. It was recommended by Quénu at the beginning of the war, and gives free access to the joint. This operation has sometimes to be supplemented by excision of the patella.

Which method should be chosen ?

It is impossible to answer this question in a few words, for these cases are complex ; but the point to insist on is that all these methods are of little use if

arthrotomy is regarded as simply an operation for drainage. In war-wounds arthrotomy should be regarded as essentially an exploratory incision, the first stage in an operation of discovery and trimming up, and not, as it has often been called, an operation for drainage. When once the foreign bodies have been removed and the joint has been cleared out, the simplest drainage incision is the best ; if, on the contrary, foreign bodies are left behind, the most elaborate arthrotomy is only too often inefficient.

Missiles left in the knee after arthrotomy for drainage have undoubtedly in some cases been well tolerated, but these are quite exceptional. As a rule, the early ablation of missiles and infective débris is essential for rapid and satisfactory recovery ; it is absolutely necessary to remove at the earliest possible moment every intra-articular missile. It is for want of understanding of this fundamental principle that so many surgeons at the front have given up arthrotomy.

If we lay down this principle, it may be said that an exploratory arthrotomy is the first step in the treatment of every wound of the knee.

How should it be done ?

(*a*) EXPLORATION OF THE WOUND OF ENTRY.— In view of the uncertainty of the diagnosis in the first few hours, and especially when radiography is not available, it is well to begin by making the incision at the wound of entry, even if it be at some distance from the joint, and to follow it up and retract its edges . As Gayet has justly remarked, this method of exploring sometimes shows that the joint has not been opened ; and, by dissecting carefully, one may be able to extract a missile situated outside the joint, though the latter is full of fluid.

I have always proceeded in this manner and have found it satisfactory.

(*b*) THE MISSILE LIES IN THE OPENING IN THE

SYNOVIAL MEMBRANE.—If the dissection leads to an opening in the synovial membrane, the diagnosis is certain: in that case it is necessary to enlarge the small opening freely but with care, and see if the missile is there. If it is seen, or felt, it is removed along with any fragments of clothing, the opening in the synovial membrane being enlarged at the same time so as to enable the surgeon to explore and clear out the joint. Generally there is no need to do more.

After carefully arresting the bleeding from the synovial vessels, which always bleed freely, the interior of the joint is dried by gauze, and the incision plugged without draining the synovial membrane, or, better still, when the patient can be kept under observation for eight or ten days, the

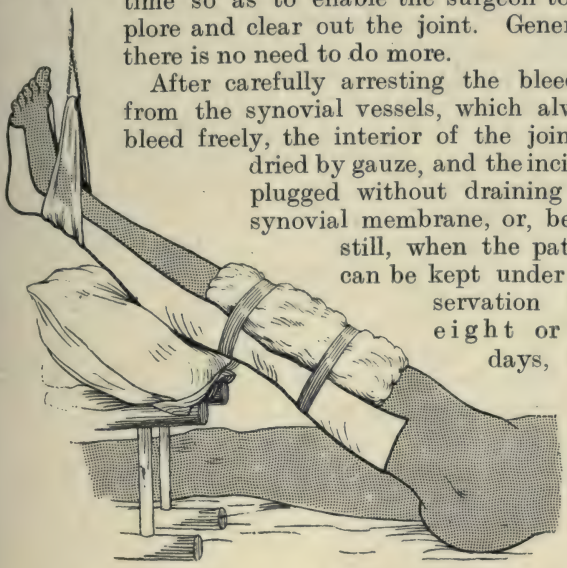

FIG. 65.—Elevated position of the knee after opening the superior synovial cul-de-sac of the knee-joint.

edges of the synovial membrane are excised, and the joint closed with catgut sutures, as Delore has advised.

Exploratory arthrotomy followed by complete suturing of the synovial membrane, which Delore and Kocher have described, is certainly the method of choice in cases that are seen early. But it should

only be used when it is possible to render the parts clean and when nothing suspicious is left behind in the wound or is met with during the operation. The more it is tried and the more rapid the operation, the more often will it be used, and the more perfect the results. If the joint is full of blood, the same method will be employed ; but if the character of the effusion is at all suspicious, it is more prudent to drain the supra-patellar pouch by Jaboulay's method. The cul-de-sac is made to project by means of forceps, which are cut down upon, and a drainage tube is inserted, flush with the joint. The dressing is completed and the foot is well raised, a posterior plaster splint immobilising the joint. The limb is supported on pillows, so that it is at an angle of 45° with the trunk.

(*c*) THE MISSILE IS LOST IN THE JOINT.—It is essential to be able to explore all the recesses of the synovial membrane, so that nothing suspicious may escape detection and removal. The only efficient method for this purpose is to open the knee by the curved subpatellar incision with its convexity downwards. Without troubling about the incision already made in order to follow the track of the missile outside the joint, the ligamentum patellæ and the pad of fatty tissue are divided transversely. The flap containing the patella is firmly seized in catch forceps, and the leg is flexed on the thigh so that the cavity of the joint can be thoroughly examined. After removing any foreign bodies, mopping out the synovial membrane, and arresting all hæmorrhage, the surgeon closes the joint with three layers of sutures—serous, tendino-aponeurotic, and cutaneous. If there is a slight injury to the bone, the synovial suturing should be so arranged as to exclude it from the joint cavity. The tendon of the patella is carefully united, and the wound of entry and the track of the missile are thoroughly excised, left open, and drained with gauze.

If it is thought well to drain the joint, this may be done through the supra-patellar pouch, and the limb well elevated. If the missile is not found, lateral drainage should be effected, and the foreign body localised and removed as quickly as possible later.

(*d*) THERE IS A PARIETAL INJURY OF THE BONE.—This condition is not always very simple : when the joint has been freely opened, parietal injuries, such as small scales of bone chipped off the femur, crushing of the articular surface of the tibia (often with destruction of its cartilage or jagged fissures of the patella), may be found. Frequently the missile is still in contact with the broken bone, in which it has made a sort of cavity for itself. In this case the fragments ought to be removed, and the bone carefully curetted : a strand of aseptic gauze is left against the bone, issuing from one of the lateral incisions, as after an ordinary arthrotomy.

If the operation is performed early and properly, these arthrotomies for extraction of missiles run a favourable course, and the wounds heal by first intention with more or less perfect recovery of movement ; but it is clear that such a method is one applicable only to wounds seen early before any sign of septic infection is present. If such exists, or if there is any doubt about it, it is best to insert drains in the lateral incisions, in case of need converting the curvilinear incision into the H-shaped incision of resection. But the ideal method is to intervene soon enough, and with sufficient attention to detail, so that the above-indicated measures may be possible.

I have collected notes of 58 cases of early extraction of splinters in the knee joint with 58 recoveries (5 my own, 6 Delore, 5 Gayet, 6 Tisserand, 14 Santy, 10 Bosquette, 1 Desplas, 11 Sencert). One of my personal cases is the more striking as there was a penetrating wound of both knees with a double cancellous fracture of the upper surface of the tibia. The patient

recovered without complications, and with extensive movements of both limbs. This result is 11 months old.

(*e*) THE MISSILE HAS PENETRATED THE POPLITEAL SPACE FROM BEFORE BACKWARDS.—The condition is not rare, and sometimes injuries of vessels or nerves accompany the joint wound. After arthrotomy, only a posterior perforation of the synovial membrane is found. Generally in these wounds, action is confined simply to draining the joint, leaving the missile alone, unless amputation is done for injury to the vessels.

Theoretically it would appear preferable to close the arthrotomy wound, leaving a drainage tube in the supra-patellar pouch, and to expose the vessels and nerves and the missile, which has been localised by radioscopy, through an incision in the popliteal space. Another method would be to divide the crucial ligaments, when, with the perforation in the synovial membrane as a guide, the missile could be sought for in the popliteal space from before backwards.

I have not seen any case of this kind, but it seems to me that I should prefer the popliteal method, since division of the crucial ligaments leads to dislocation of the knee, which is dangerous from the point of view of the ultimate usefulness of the joint.

3. **Resection of the Knee and Ablation of the Patella.**—When there is evident fracture, or when exploratory arthrotomy has revealed extensive injuries to the bone, removal of the missile and foreign bodies, preventive drainage, and simple esquillectomy do not suffice. In order to save the patient's life and to safeguard the functional usefulness of the limb, it becomes necessary to perform a primary resection.

This needs proof.

There can be no longer any doubt about the necessity of bone-operations in these cases: the gravity of the sepsis which occurs at the seat of fracture is such, that all surgeons who at the outset had preconceived

ideas on the subject have been quickly converted to free esquillectomy and clearing; but many are unwilling to consider the future orthopædic result (Potherat, Picqué). The surgery of the bones, however, does not date from the present war, before which it was known that atypical resections give poor results, that removal of the condyle may lead to troublesome malposition of the leg, and that to obtain a good ankylosis, two bony surfaces which have been freshly made, not a cartilaginous surface and a recent section of bone, must be placed in contact. Some surgeons have said that union between bone and cartilage has occurred. But this is only apparent, because the cartilage has disappeared in consequence of inflammation, which has therefore done, after much pain and danger, what one cut of the saw would have done at once, simply and without risk.

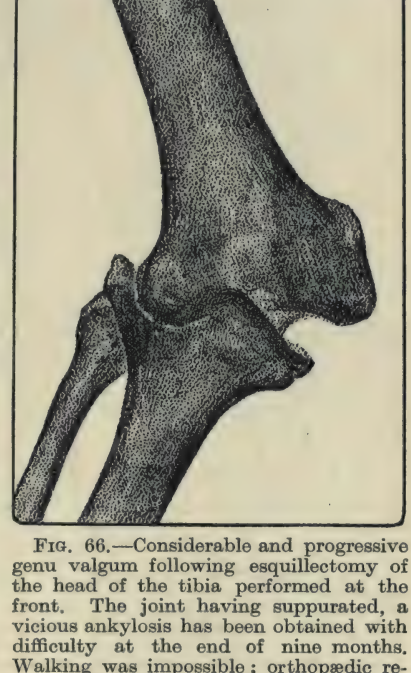

FIG. 66.—Considerable and progressive genu valgum following esquillectomy of the head of the tibia performed at the front. The joint having suppurated, a vicious ankylosis has been obtained with difficulty at the end of nine months. Walking was impossible; orthopædic resection of the knee was necessary and gave a good result. It would have been more simple to perform a typical resection at the outset.

In good bone-surgery it is absolutely contra-indicated to perform, on the ground of economy, what, orthopædically speaking, are illogical operations; the economical surgery is not that which sacrifices least bone, but that which gives the maximum result in a minimum of time and risk. At the knee, typical resection alone fulfils these conditions.

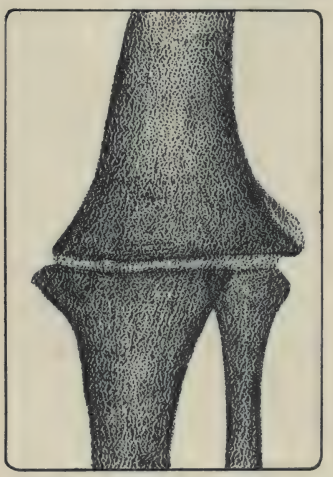

Fig. 67.—Ankylosis after typical resection of the knee for fracture of one condyle caused by shell-splinter.

If the patella is comminuted, the whole of it should be removed subperiosteally; esquillectomy is not sufficient. If the femur, or the tibia, or both, are involved, the classical operation of resection of both bones should be performed by removing the patella and making the section through the epiphyses if possible. In no case should it be limited to the ablation of one condyle, or to resection of the tibia only.

Done early, typical resection gives excellent results, as Viannay was the first to show. I have collected 37 cases (7 of the patella and 30 of the femur and tibia) more or less early (of which 3 cases were my own), with 36 recoveries and 1 death.

One can say, then, that all non-parietal fractures of one or other bone of the knee when the vessels and nerves are intact should be treated by primary resection of the patella or of the femur and tibia.

4. **Amputation.**—Primary amputation at the very outset is called for in bony injuries which are so exten-

sive that resection is impossible or dangerous. When, for example, the condyles and the shaft of the femur are split up, when there are fragments as high up as the middle of the bone, which is not rare and necessitates in consequence a sacrifice of over five inches of its length, the indication to amputate is undoubted, because the risks of infection with so much loss of substance are too considerable, and in addition the only possible result must be deplorable from an orthopædic point of view.

Similarly, when there are injuries of the vessels and nerves, resection is a gamble ; immediate amputation is called for. Functionally it is incumbent on the surgeon to obtain a stump which is solid and free from pain. If there is no hope of giving the patient a leg capable of carrying the weight of his body, the loss of the limb is a necessity which cannot be avoided.

The prognosis of these amputations is, as a matter of fact, always grave : the patient, who is in a state of severe shock, affords the surgeon only the choice between interfering at once and seeing him die of shock, or waiting to see him die of sepsis.

In principle, it is better to interfere at once, after having tried to stimulate the patient before a good fire, and in a warm bed, with large doses of camphorated oil. It has often appeared to me that morphine would do much to improve the condition. Preoperative transfusion, where possible, is the heroic remedy for these cases of severe shocks.

To tabulate the foregoing : for articular bullet wounds, simple immobilisation is suitable ; for foreign bodies in the joint, arthrotomy and immediate extraction ; for parietal fractures, primary esquillectomy ; for smashed patella, early excision of that bone ; for fractures destroying the statics of the joint, typical resection ; for extensive crushing with lesions of the vessels, amputation.

III. Operative Technique

For the surgery of the knee, lumbar anæsthesia by novocaine-adrenalin is an excellent method; in cases of shock, and of crushed joints, it should certainly be the method selected whenever it is possible to employ it.

The directions given above for the performance of a primary arthrotomy in different cases suffice for the performance of that operation. I will only add that the semi-lunar cartilages ought always to be preserved if they are intact, and that under no circumstances should the crucial ligaments be cut. Having said that, nothing further remains but to deal with resection.

FIG. 68. — H-shaped incision of typical resection.

This should be performed in accordance with the classical directions of Ollier for a typical resection carried out in healthy tissues, with a sharp rugine, carefully sparing the periosteum.

It is done in the following manner:

(*a*) *Incisions.*—Following a previous transverse exploratory arthrotomy, as it often does, resection will always be performed by an H-shaped incision made when the knee is flexed. The transverse branch of the incision does not go beyond the lateral ligaments, but is long enough to permit the condyles of the femur to be dislocated through it. From the ends of that incision, which is three and a half inches long, two vertical incisions are made, the greater part of each of which is above the horizontal line, at either side of the patella.

(*b*) *Removal of the fractured Bone.*—When the injuries have been well exposed, and the clots removed, any large fragments of the femur or the tibia which are

more or less movable are stripped of their periosteum with the cutting rugine after they have been fixed with forceps. This renders it easy to preserve their entire periosteal covering, which is very useful for the after-consolidation of the limb.

After the extensive damage done by the missile has been cleared away, all small free splinters are removed in a similar manner, and it is only when this process of clearing out the damaged area has been completed that the articular operation is proceeded with.

(*c*) *Removal of the Patella.*—The patella should be removed with the rugine, as it is more troublesome than useful in an ankylosed knee ; the culs-de-sac around it are dangerous recesses, from the point of view of sepsis. Sub-periosteal removal of the bone leaves clean and smooth surfaces and sound tendon and periosteum, which will give a good anterior covering to the ankylosis.

(*d*) *Excision of the Synovial Membrane.*—Excision of the synovial membrane is then performed as completely as possible with forceps and scissors. The supra-patellar pouch is dissected out very carefully, so as to remove the whole of the large sac and the synovial pockets from which septic absorption might otherwise take place ; the lateral prolongations over the sides of the upper end of the tibia are similarly treated. The posterior ligament of the joint is stripped and identified with great care, and the state of the vessels examined through this structure.

(*e*) *Section of the Bones.*—After all the normal as well as the damaged structures of the joint have been removed, there remains an irregular roughened end to the femur which is only in limited contact with the tibial surface, if at all. The end of the femur is removed with the saw, without taking any notice of fissures which may run up the shaft of the bone ; then the cartilaginous surface of the tibia is removed in the form of a thin layer.

(*f*) *Fixation of the Femur and Tibia.*—This is not absolutely necessary; simple juxtaposition of the femur, by pushing it against the cancellous tissues of the tibia, as Viannay does, apparently suffices to ensure bony union. However, if the operative conditions are favourable, and if one can count upon the absence of sepsis, there is every advantage in inserting a metal suture, two hooks for example, as L. Berard recommends. The operator must see that his assistant keeps the limb in good position while the hooks are being inserted, or while the dressing is being done.

(*g*) *Sutures.*—When there is extensive loss of bone, the soft parts are redundant and form cavities around the bones, which should be lightly packed with aseptic gauze, whilst a drainage tube is inserted on either side opposite the line of junction of the bones, at right angles to the long axis of the limb. The tendon of the patella and the soft parts covering the front and sides of the joint are accurately united with catgut sutures. Cutaneous sutures should be inserted in front only; it will be well to put in none in the region of the wound made by the missile, and simply to insert some gauze between the edges of the skin wound. This avoids infection of the cellular tissue and the formation of pockets of pus around the joint, while the healing process is much accelerated.

IV. Post-Operative Treatment

1. **After Arthrotomy.**—Whatever may be the extent of the operation performed, the knee, under a dressing of aseptic gauze, is immobilised in a posterior moulded plaster splint of the usual type, extending half round the circumference of the limb, and from the middle of the thigh to the end of the foot.

The limb is raised on pillows and kept elevated by a figure-of-eight bandage round the instep, fastened to

something above the bed, such as a screw in the ceiling, or a bar above the bed.

After an arthrotomy where sutures without drainage have been used, the first dressing should be delayed as long as possible if all goes well; towards the seventh day the stitches and any gauze along the track of the missile are taken out. If drainage has been used, one can wait several days. Gayet recommends the twelfth day and advises that elevation of the limb should be continued until the wound has closed. As a general rule, the less one touches the dressing the better.

Towards the fifteenth day, gentle movements are commenced by making the patient perform small active movements of the quadriceps, and by massaging the limb. This should be continued each day, without attempting any movement by instrumental or mechanical means. Walking is allowed at the end of three weeks, if the movements have produced no reaction in the joint. During the first week the patient wears a dressing that exerts pressure on the joint, preventing movement of the knee when walking, but he will be allowed to walk with his knee free in a month.

If there has been injury to the bone or the vessels, immobilisation will be kept up for a month.

2. **After Resection.**—Immobilisation has considerable influence upon the favourable post-operative progress of patients who have undergone resection, especially if the bones have not been fixed together by metal hooks.

In a resection running an aseptic course the question is simple, but often, when there is free oozing from the wound, it is impossible to procure permanent immobilisation during the first few days. The best way is to use for that period the classical posterior moulded plaster splint, provided with an impermeable lining in the middle, and put on while the patient is still under the anæsthetic; or even, paradoxical as it

may appear, an anterior splint of the same material, embracing half the circumference of the limb from the top of the thigh to the foot. This is perhaps the best method of securing temporary immobilisation, for the plaster casing is easy to take off without moving

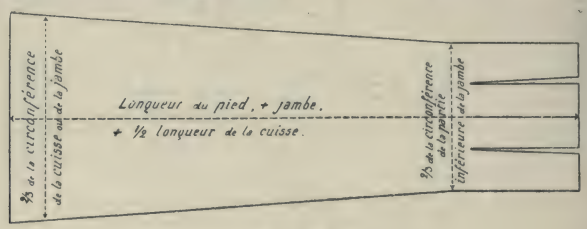
⅔ de la circonférence de la cuisse au dessus de la jambe
Longueur du pied + jambe.
+ ½ longueur de la cuisse.
⅔ de la circonférence de la partie inférieure de la jambe

FIG. 69.

the limb, while it renders it quite immovable, and does not become softened as does the posterior splint (see fig. 63). A large and rather wide wooden splint, slightly hollowed out in the middle, with a foot-piece, like Bœckel's splint, reaching as high as the middle of the thigh, may be used: this is provided with an

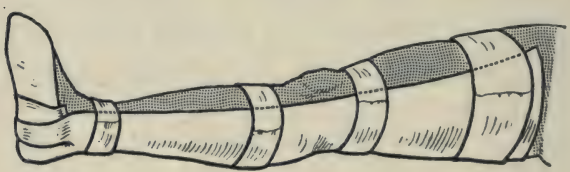

FIG. 70.—Grooved leg-splint for transport of cases of wounds of the knee and of the tibio-tarsal joint.

impermeable covering at its middle and is fastened on with the bandages.

The dressing should be left untouched as long as possible, especially when the general condition of the patient is good. Generally it is necessary to change the superficial layers on the third or fourth day. It

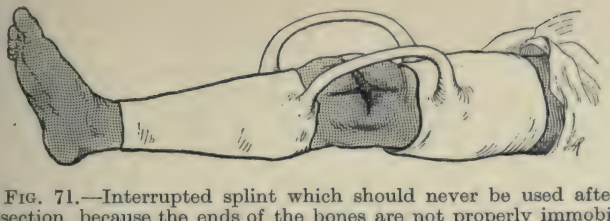

FIG. 71.—Interrupted splint which should never be used after resection, because the ends of the bones are not properly immobilised and backward displacement of the tibia may ensue. This casing should only be used after arthrotomy, and only then when the lateral ligaments have not been destroyed.

is well to change the deeper ones a little later. Permanent immobilisation may sometimes be effected as early as the eighth day. If the wound remains aseptic, the simple posterior gutter splint is the best appliance for this purpose, but sometimes the wound oozes a great deal, and then the splint gets constantly wet, and softens so that it no longer immobilises the limb, and has to be renewed frequently. The interrupted plaster appliance seen in fig. 71 is then a tempting form of splint to use, but in the knee it has great drawbacks: if used before the soft parts have shrunk, the plaster bandages immobilise badly and the popliteal space is not supported. A disastrous backward displacement of the tibia occurs, and the resulting ankylosis is bad (fig. 72). The interrupted splint therefore must not be used too

FIG. 72.—Bayonet-shaped ankylosis following immobilisation in an interrupted splint without a posterior support.

early : if possible, a fortnight at least should elapse before it is applied. If it is necessary to apply it sooner, it must not be forgotten that the apparatus is only temporary ; further, a small posterior splint must always be added to the circular plaster casing round the thigh and the leg, so as to maintain the bones in position. Lastly, it is necessary that the plaster should envelop the foot, so that the tibia can be fixed. These patients do better when the leg is raised a little ; and an appliance with supports below should accordingly be chosen.

These remarks will show that it is very difficult to get an apparatus which prevents the knee from moving, which is all-important.

The steps of the procedure are as follows :

The lower limb is firmly immobilised in extension by a reliable assistant, the patient being drawn to the edge of the table, and the assistant standing between his thighs. A large towel is then passed under the knee, which is covered with a small aseptic dressing without any cotton wool. The towel supports the limb during the application of the first part of the plaster.

FIG. 73.—Method of holding the knee during the application of the plaster. An assistant supports the heel at the same time.

This comprises :

(1) A plaster bandage encircling the thigh from the upper third as far down as the dressing at the knee, and reaching lower behind than in front.

(2) A plaster bandage encircling the leg, extending higher behind in the popliteal space than in front (where it reaches the tubercle of the tibia), and covering the heel. The foot is kept at a right angle with the leg.

(3) Two iron rests made as seen in fig. 74 : the vertical limbs below the knee are higher than those above it, so that the limb is slightly inclined upwards towards the foot. These rests are incorporated in the plaster bandage, so as to form two lateral supports, inclined a little outwards.

(4) A small posterior plaster splint, of the width of the hand, applied over the popliteal space between

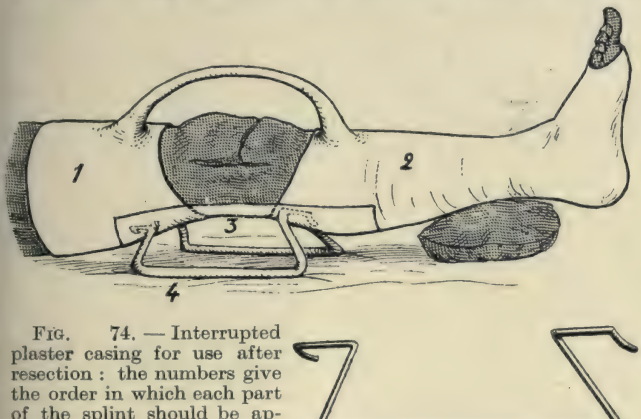

FIG. 74. — Interrupted plaster casing for use after resection : the numbers give the order in which each part of the splint should be applied.

the two circular portions of the apparatus, with which it will be incorporated.

(5) Another bracket can be incorporated at the middle of the upper surface so as to bridge over the knee from below upwards, if it appears useful : it is not generally used.

When the splint has been completed, the edges of the central gap can be cut away as required, and the anterior parts of the foot and instep are exposed. The plaster cast thus made cannot, and ought not, to be kept on the limb until the end of the case. At the end of a certain time it will allow some play, and the leg will be too free ; immobilisation is no longer

satisfactory, and displacement, though late, is still possible. This must be watched for, and there must be no hesitation in applying a fresh apparatus.

When is it necessary to remove the gauze drains for the first time? The drainage tubes can usually be removed towards the sixth day, while the gauze is left in position and moistened with a saline solution. Towards the eighth day this gauze is drawn out little by little; towards the tenth day it is completely removed and replaced by fresh gauze, either soaked in saline solution, or dry, according to the condition of the wound. Insolation and hot air treatment are now commenced. If everything goes on well, the dressing can be postponed for a still longer period, and fifteen days may elapse before it is renewed.

If there is the least rise of temperature towards the tenth or twelfth day, the occurrence of an abscess must be suspected: this is usually found in the calf.

Consolidation of the limb generally requires three months, but walking should not be allowed before four months, and even then only after the application of a plaster bandage thoroughly immobilising the knee.

After consolidation, a leather covering, moulded to the limb, with lateral metal supports, should be worn for a year, for fear of secondary deflection of the knee.

3. **After Ablation of the Patella.**—The course will almost always be favourable. The first dressing will be delayed as long as possible, up to the eighth or tenth day. Movements are commenced as soon as cicatrisation is complete, that is to say about the end of three weeks or a month. Improvement is rapid, and as early as the second month the result will be very satisfactory: extension normal, flexion half the normal.

V. Evacuation of Patients with Knee Wounds

No one with a wound of the knee (except with the simple perforating bullet wound) ought to be evacuated without surgical exploration.

If this has allowed of easy extraction of a missile, the patient may be evacuated at the end of five or six days in a plaster casing, if it is really necessary, but it is better to keep him twelve days.

If there has been a free arthrotomy, evacuation should be delayed until the twelfth day. A patient who has undergone resection ought to be kept as long as possible, at the least fifteen days if all goes well. As a rule, only cases which have had a normal temperature for several days, and in which there is not much oozing, should be evacuated.

For evacuation, the limb should always be immobilised in a plaster casing. If an interrupted plaster splint has not yet been applied, the posterior half-gutter or the large pelvi-pedial splint is the best apparatus for transport.

The journey should not exceed twenty-four hours in duration, and it would be better not to exceed twelve hours.

VI. Treatment of Patients seen late or after Evacuation

The patient, correctly operated upon by arthrotomy or early resection, generally recovers uneventfully.

It is quite different with those who have been operated on insufficiently or not at all. There are no fractures met with in war that are more difficult to treat in the secondary stages.

Let us take first those who have not been operated upon.

1. *A patient arrives on the second or third day after the injury with an acute suppurative arthritis of the knee.* What should be done ?

(*a*) After determining by radiography, if possible, the presence and the exact position of a foreign body and the absence of a fracture, the orifice of entry is freely incised down to the synovial membrane: arthrotomy is then done by a vertical incision, four inches long, on each side of the patella. Through these one can generally extract any foreign body and the missile. Then two postero-lateral incisions are made for drainage; in some cases (*e.g.* missiles at the back of the joint, swelling, popliteal œdema and pain) an incision into the post-condylar cul-de-sac is made through the popliteal space. But the risks of popliteal drainage must not be forgotten. Many patients treated in that way have died of secondary hæmorrhage. The popliteal incision ought only to be an incision to facilitate search for the missile, and not one for drainage. To establish this latter, incision of the supra-patellar pouch with the foot elevated is the best method. A drainage tube should be placed in each opening in the synovial membrane to keep it from closing, but it is not necessary to push the tubes deep into the cavity of the joint, and still less so to make them pass right through it. The serous membranes tolerate these foreign bodies very badly; often, after drainage thus effected, the temperature is only reduced by doing away with all the drainage tubes. No transverse tubes, therefore, should be used.

If at the end of two or three days this drainage has not arrested the sepsis and brought down the temperature, amputation through the lower third of the thigh should be performed at once before the patient has gone too far downhill. It should be done by the circular method, with or without lateral incisions, and no sutures should be inserted. The muscles are profoundly septic, infiltrated and œdematous; in order to expose the tissues, the flaps should be temporarily turned back, for the least retention of discharges is very dangerous.

Perhaps some of these cases of arthritis might be amenable to excision of the synovial membrane. It might be tried. I do not dare to recommend it, not having had any experience of it.

(*b*) If a fracture, however limited, exists, resection of the knee should be performed at once; the danger arises as much from osteomyelitis as from arthritis, if not more. And, as Poncet taught, the chances of saving the limb are improved in proportion to the nearness of the time chosen for resection to the onset of the infection.

In these cases, drainage of the joint is absolutely without effect; any exceptions that can be cited do not invalidate the general rule.

It is necessary, then, to treat these cases of articular osteitis at the outset by resection of the knee. It is often said, in connection with these wounds, that arthrotomy, resection, and amputation ought to be done, one after the other, when a primary operation does not succeed in presenting the onset of infection. There is no conception more illogical or more dangerous. Successive operations are always too late: it is most important to choose at the outset the best method of intervention, and for septic fractures of the knee, the only good one is resection, done as early as possible. Resection ought not to follow arthrotomy: it ought to be preferred to it whenever there are injuries to bone. It should even be employed when there are only simple injuries to the cartilage (erosions or necrotic ulcerations).

L. Berard has shown cases that are very instructive from this point of view, and with Tuffier, Quénu, Viannay, and Gayet, he has reported cases favourable to early secondary resection.

But it must be recognised, as all those who have recommended it have said, that (intra-febrile) secondary resection is far from giving uniform results: it only succeeds if it is performed early, for injuries

which are not too extensive, before medullary infection has occurred, and when the damage to the soft parts is not too great. Indeed, it is only justified when it does away completely with the area of the bone-sepsis. Contrary to what has often been said, it is by no means the most effectual form of articular drainage : so far from being that, it does not drain at all.

If time is lost in performing it, it is a great gamble, and immediate amputation ought to be preferred to such dangerous ultra-conservative treatment. In any case, if resection is not followed by a rapid fall of temperature and a cessation of the general symptoms of sepsis, amputation should be done forthwith.

As secondary (intra-febrile) resections are performed while suppuration is at its height, some surgeons consider it useful to apply continuous extension to the leg, so as to maintain a cavity for drainage between the two separated bones. This is not a practice to be followed : intense septic absorption occurs from the recent bone sections which are thus bathed in pus ; the cancellous bone inevitably becomes inflamed and infected, and even if the patient recovers from a slow septicæmia, the ultimate consolidation of his limb is gravely jeopardised. It is much better to stake everything and do the operation exactly as has been indicated above for primary resection ; it is reasonable to hope that infection will soon cease, and that the freshly cut bony surfaces, carefully juxtaposed, will not become fresh centres of osteitis. In that event we may proceed as if we were in the presence of a recent wound.

To sum up ; when we have to deal with a suppurative arthritis not yet treated, arthrotomy with drainage and resection should be considered. Arthrotomy with extraction of the missile and drainage is suitable for simple synovial injuries ; resection is the method for articular osteitis. If either mode of treatment proves a failure, amputation should be done without delay.

2. *The patient has been operated upon insufficiently or has been badly looked after.*—In this very frequent case the patient arrives at the base with an enormous infiltrated knee, œdematous, painful, and riddled with drainage tubes (I once found eight, measuring together 55 inches in length); he has been operated upon too late, or foreign bodies have been left in the joint. His condition gives the impression that any intervention would be dangerous, that it might give an impetus to the disease by provoking an acute septicæmia, and that then amputation would become necessary.

In short, the decision is always a very delicate one; it should never be made off-hand, except where amputation is obviously urgent. At first the patients should be kept at rest, and, if necessary, means adopted to secure better immobilisation. For five or six days, if one's hand is not forced, one should study the temperature chart, examine radiographs, determine the existence of foreign bodies and define their precise position. Once the necessary information is in hand, various alternatives present themselves.

(*a*) There are many cases where amputation should be done without hesitation; it should be done (by the circular method in the lower third, with a very long skin flap, and no sutures) when the temperature is hectic in type; when the constitutional condition is very depressed and there are albuminuria and œdema of the ankle on the sound side; when, by radiographs, there are seen to be extensive bony injuries (femoral or tibial); when the atrophied thigh shows the dry œdematous skin of chronic œdema which the finger pits (a condition in which phlebitis of the small veins round the joint is to be feared); when there are pockets of pus behind, in the thigh and the leg, which have defied well-planned incisions; and, lastly, when there is secondary hæmorrhage.

These are questions of degree, and no absolute rules

are possible. But speaking generally, in the cases indicated above, there is everything to gain by rapid amputation. It is also necessary to amputate in the case of those who have had a resection done after arthrotomy has failed, and in whom the two successive operations have been done too late.

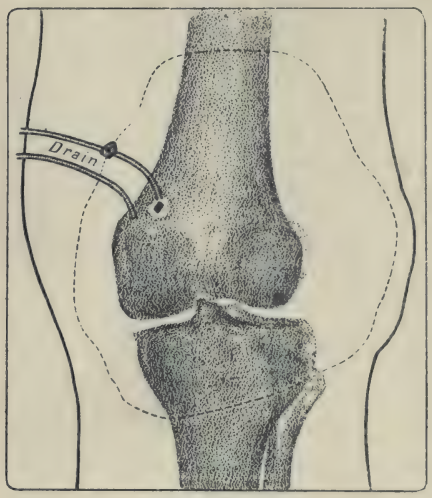

FIG. 75.—Radiograph showing the defects of drainage after arthrotomy. The patient from whom it was taken had been operated upon primarily at the front by double arthrotomy, four large drainage tubes being used. He was evacuated at the end of three weeks with an enormous knee, which was rounded and painful, and a temperature standing at 38·5°.

On arrival, an exploration with Bergonié's "vibreur" revealed the two foreign bodies shown in the radiograph: one was in the track of a drainage tube, the other in contact with the bone at the very spot where the tube impinged. It was sufficient to incise the track and remove the projectiles. A primary operation well performed would have obviated ankylosis.

(*b*) There are cases where resection ought to be tried.

These are the patients whose general condition is still good; who have no serious septicæmia, and in whom the bony injuries are evidently not very extensive.

Resection should be an early operation, even when suppurative arthritis is present, and not a final operation after a failure by arthrotomy.

(*c*) There are cases in which resection may be tried.

These are cases in which a free arthrotomy has not succeeded in reducing the temperature and arresting sepsis. But one should be under no delusion as to the efficacy of resection in these patients. Some very remarkable successes have been reported, but how many more failures have occurred because the operation has been done too late! If in doubt, it is better to decide upon amputation.

(*d*) There are cases where the fractured patella must be removed. Simple ablation is sometimes sufficient to cause the disappearance of the septic phenomena; the parts under the quadriceps must then be plugged wide open and exposed to the air.

(*e*) There are cases where it is sufficient to open up a collection of pus which has passed unnoticed, *i.e.* an abscess of the popliteal space or the leg, or an abscess between the incisions. I have often caused the temperature to fall and have stopped the sepsis by slitting up the tissues between one drainage opening and another; in the track between them there were burrowing abscesses, sloughs, or fragments of clothing.

(*f*) There are cases where it is necessary to remove foreign bodies from a shut-off synovial pocket. This should be done with as little injury as possible.

(*g*) There are cases where an enlarged knee ought to be treated as a tuberculous synovitis, by deep intra-articular cauterisations with the largest available cautery. Like Delore, who, with Kocher, has called attention to this condition, I have seen a large globular knee, with pale granulations and having all the appearances of white swelling, much improved and eventually cured after energetic cauterisation.

(*h*) There are cases where it is sufficient to do away with drainage tubes and pack the drainage incisions with gauze, so long as the temperature is not raised and there is neither missile nor fracture.

This effect upon the progress of wounds caused by

doing away with drainage tubes is recognised in the case of the pleura ; a similar effect is not surprising when another serous membrane is in question. Small residual abscesses may form in the sinus, but it will be easy to open them later on.

(*i*) Lastly, there are cases in which one must temporise, with no great hope of final recovery ; such as cases of phlebitis, unless that has been caused by the presence in the popliteal space of a missile, which should then be removed as quickly as possible.

3. *A patient who has had resection done at the front arrives with symptoms of sepsis.*—Here, again, one cannot give any certain indication ; as a general rule, one will begin by observing the effect of rigorous immobilisation for two or three days. If absolute rest in a plaster casing does not stop the septic phenomena, one will look for pockets of pus behind, in the calf, and in the hamstring muscles, or even in the course of the drainage tubes. One will often find in this way a local cause explaining an alarming degree of sepsis, and recovery can be easily obtained.

But when the symptoms of sepsis do not yield, when the constitutional condition is gravely affected, when there is profuse suppuration with considerable separation of the femur and tibia, and especially when there has been secondary hæmorrhage, the limb must be amputated without delay. It is the only means of saving life.

4. *A patient is seen late, with a fistulous ankylosis, or with marked deviation of the knee.*—These vicious ankyloses are not very frequent, but they exist. I have twice seen a very marked genu valgum following an ablation of the external condyle. Many cases will be seen in the future, if the ideas of certain surgeons on the substitution of limited esquillectomy for the typical operation of resection, without regard to orthopædy, prevail at the front. These patients ought to be treated by a classical orthopædic resection. The

operation is easy, in spite of the ankylosis, for the bone is generally soft. One can saw close up to the popliteal space ; there, the section can be completed by fracturing the remaining bone by slowly flexing the knee. The patella is removed sub-periosteally, and the extremities of the bones nailed together. The operation gives excellent results.

CHAPTER VII

WOUNDS AND FRACTURES OF THE ANKLE

I. Anatomical Types and Clinical Course

BULLET wounds of the ankle are not rare in a war of movement, but they are exceptional in trench warfare, in which almost all wounds in the lower part of the body are the result of splinters of grenade or shell.

(a) *Bullet wounds* occur in considerable variety, of which the most frequent is the transverse bullet track with a comminuted fracture of the astragalus, or a simple perforation of the os calcis, the type of fracture differing essentially according to the bone involved. These wounds are not much infected and do not give rise primarily to severe septic symptoms; but they often develop persistent sinuses, whilst deep in the bone a progressive rarefying osteitis develops. This fact deserves notice, for in all other parts of the body

FIG. 76.—Bullet wound in the heel in front of the tendo Achillis. A sinus with slight suppuration.

the wounds caused by long-range bullets usually heal readily and without trouble. I have been able to follow the course of such wounds in two cases. In the case of a soldier, the posterior edge of whose astragalus had been just touched by a bullet, I thought I could safely wait after having simply immobilised the foot and the leg. At the end of three months healing had not occurred, and the parts behind the malleolus remained swollen and painful despite a limited curettage, and so I explored them by means of a suitably wide incision. Through this I removed the astragalus, which was traversed from behind forwards by a Y-shaped fissure, covered with flabby granulations. The os calcis, which was the subject of a rarefying osteitis, was curetted until the compact bone was reached, and after that recovery took place naturally in three months (see figs. 76, 77, and 78). In the case

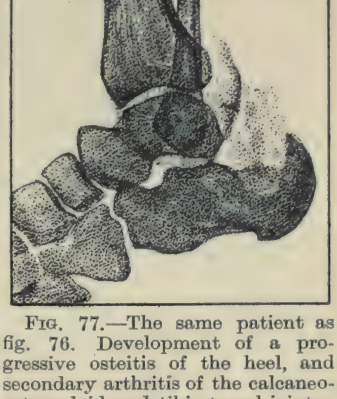

FIG. 77.—The same patient as fig. 76. Development of a progressive osteitis of the heel, and secondary arthritis of the calcaneo-astragaloid and tibio-tarsal joints.

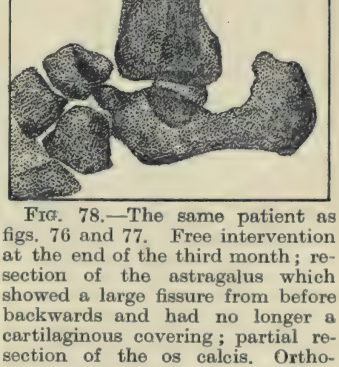

FIG. 78.—The same patient as figs. 76 and 77. Free intervention at the end of the third month; resection of the astragalus which showed a large fissure from before backwards and had no longer a cartilaginous covering; partial resection of the os calcis. Orthopædic and functional results eventually good.

of a patient who came from the front with the foot simply immobilised in a plaster case for a perforation of the os calcis by a bullet, sustained seventeen days before, I watched in radiographs the progressive extension of a rarefying osteitis which had attacked the joint between the astragalus and os calcis; it became necessary to remove both bones sub-periosteally in order to get healing (see figs. 79 and 80).

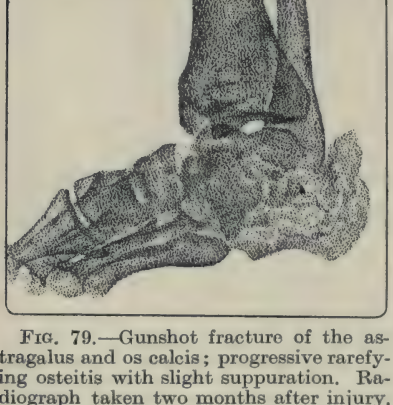

FIG. 79.—Gunshot fracture of the astragalus and os calcis; progressive rarefying osteitis with slight suppuration. Radiograph taken two months after injury. The spread of the osteitis to the anterior tarsus is to be noticed.

(b) *The injuries by splinters of grenade or shell* expose the patient much more to the inroads of sepsis of a more acute character. Sometimes the shell splinter has been driven into the bone, burying itself firmly in the astragalus or the os calcis, without giving rise to any radiating fissures, while sometimes the

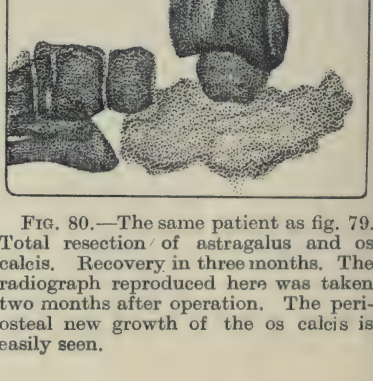

FIG. 80.—The same patient as fig. 79. Total resection of astragalus and os calcis. Recovery in three months. The radiograph reproduced here was taken two months after operation. The periosteal new growth of the os calcis is easily seen.

bone or bones are traversed by them from one end to the other. According to the direction taken by the projectile, there are different types, a knowledge of which is of some practical interest.

Injury to one bone :

(*a*) Transverse fracture of the astragalus, with four or five fragments. The most frequent type.

(*b*) Complete or incomplete sagittal fracture with two more or less unequal fragments.

(*c*) A tunnel through the os calcis.

(*d*) Splintering of the posterior part of the os calcis.

Injury to more than one bone :

(*a*) Tibio- or fibulo-tarsal combination. Fracture of a malleolus and oblique fracture of the astragalus with transverse fissuring.

(*b*) A combination of fracture of the astragalus and the os calcis sometimes with nondescript medio-tarsal complications (old type ; involving scaphoid-astragalus-os calcis).

As a rule, in these different fractures, radiography gives little help ; a fracture without displacement does not show, and one always finds more than is indicated.

Whatever may be the anatomical type, rapidly progressive septic infection is not immediately manifest, except where laceration of the tendon sheaths exposes them to diffuse phlegmonous inflammation. More often an acute articular osteitis calling for amputation of the leg or a less acute form becoming chronic may develop. The least movement is painful ; there is moderate fever (38·6°C. = 101·5°F.). The general health gradually becomes bad and the patient assumes the characteristic appearance of a man suffering from septic absorption without much suppuration. The aspect is that of toxæmia ; the skin is dry and yellowish-white, the eyes bright, the eyelids rather swollen, the features drawn, the expression anxious ; until, finally, in despair, one performs amputation of the leg.

(c) *Partial destruction of the Foot.*—A moderate-

sized shell-splinter or an explosion of a hand-grenade striking the foot tears away part of the foot, a condition difficult to describe because the appearances are so varied. Through the gaping skin wound are seen torn tendons, vessels twisted and no longer bleeding, or else gaping and giving rise to severe hæmorrhage, joints opened and bones broken or crushed, notably the os calcis, the posterior part of which is often torn away. Unless one intervenes at once, rapid and disastrous sepsis sets in and necessitates amputation on the second or third day.

II. Primary Therapeutic Indications

In all these wounds, if one waits, infection is a foregone conclusion: it is absolutely necessary to perform a complete clearing operation as rapidly as possible, removing foreign bodies, sloughs, and splinters of bone.

Except in the wounds with punctiform openings, which are very rare, and amenable here as elsewhere to simple immobilisation, intervention is a necessity. What must be done? Three operative methods are possible.

1. **Clearing out the wound combined with Esquillectomy.**—This operation is suitable for:

(*a*) Blind wounds caused by shell-splinters where the missile is fixed in the bone and there are no radiating fissures. In these cases early removal of the foreign body, followed by curetting of the bony cavity, short of a sub-cartilaginous hollowing out of the head and body of the astragalus, suffices to prevent sepsis, and even to arrest it if it has already set in. If the osseous lesion turns out to be more considerable than appears at first, and the curetting happens to reach the cartilaginous covering of the head of the astragalus for example, the cartilage should be clipped away. It is not necessary to undertake a more complex opera-

tion, since simple resection of the head of the astragalus gives satisfactory results (Ollier); the loss of substance is made good by fibrous tissue interspersed with bone particles; the scaphoid is carried backwards, and, except for some diminution in length of its inner side and an increase in the height of the arch, the shape of the foot is not materially altered.

When, on the contrary, the curetting of the astragalus leads to the loss of the whole of the posterior part of the bone, it is better to perform complete excision of the astragalus: unless this is done the tibio-fibular arch loses its support and comes down upon the os calcis, the head of the astragalus is thrust up over the anterior edge of the medio-tarsal joint, the orthopædic result is bad, and the foot is ankylosed and painful. There is thus no economy in doing a resection confined to the body of the astragalus.

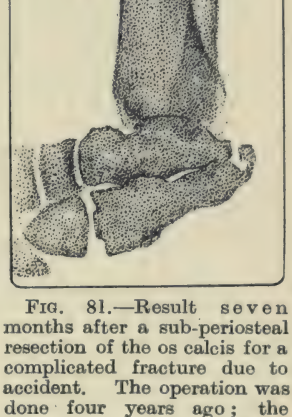

FIG. 81.—Result seven months after a sub-periosteal resection of the os calcis for a complicated fracture due to accident. The operation was done four years ago; the functional result is excellent.

In the case of the os calcis, on the contrary, hollowing out of the bone is the operation of choice, not only in blind wounds with the missile *in situ*, but also in the majority of the complete fractures caused by shell-splinters. I have several times scraped out the whole of the upper part of the bone for severe fractures, preserving only its plantar surface, the great tuberosity, and the insertion of the tendo Achillis. The results have always been perfect from the orthopædic point of view. Complete resection is only rarely indicated, but in a case of total destruc-

tion, there need be no hesitation in employing it; in spite of the many inconveniences of which we shall speak (p. 176), it is a very good operation. I was once able to follow up a patient from whom I had removed the whole of the bone for a comminuted fracture: the periosteum had regenerated a solid calcaneal mass of bone, the work of the foot was well performed, walking was painless, and there was scarcely any lameness. I am at the present moment treating a patient of Gazet's in whom the result is excellent, in spite of great loss of the tibial soft parts.

FIG. 82.—Sub-periosteal resection of the os calcis for fracture by shell-splinter. The periosteal regrowth of the calcis is well shown. Four months afterwards cicatrisation was complete: the astragalus was up against the arch; the os calcis is represented by a dense layer of periosteum.

Esquillectomy is also well suited to certain combined injuries of the tibia and astragalus: this will be considered in connection with resection. In short, atypical partial operations are indicated for blind fractures with the missile *in situ*, for injuries localised to the head of the astragalus, and for fractures of the os calcis.

2. **Sub-periosteal Resection.**—In the ankle, resection really means ablation of the astragalus, rather than ablation of the astragalus plus resection of the articular surfaces of the tibia and fibula. In military surgery it is the same thing: one should never do complete tibio-tarsal resection, that is to say, remove the astragalus and the tibio-fibular joint, any more than

one should remove both os calcis and astragalus for calcaneo-astragaloid injuries. As Ollier has clearly established in tuberculous lesions, the cavity made by sub-periosteal resection of the astragalus gives sufficient room to carry out by means of local operations efficient treatment of fractures involving the malleoli, the astragalus, and os calcis.

Ablation of the astragalus is indicated, then:

(*a*) *In Fractures limited to the Astragalus.*—Immediate excision of the astragalus is the method of choice in these cases, whatever be the agent causing the fracture, because it prevents all possibility of osteo-articular infection, and also because it is the best means of treating the fractures themselves. In peace-time the conclusion had been arrived at that immediate excision of the astragalus was the ideal method of treatment for simple fractures, because, if left to themselves, they generally resulted in painful ankylosis. In military surgery there is no reason why it should be otherwise: a fracture of the astragalus is, strictly speaking, intra-articular, and its union is exposed to the same painful disadvantages as is the union of a simple fracture.

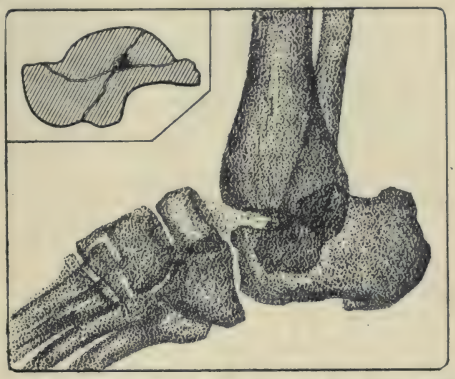

FIG. 83.—Primary resection of the astragalus for fracture by bullet. Aseptic course. Recovery in one and a half months. Very satisfactory result at the end of six months; able to walk with ease and without pain.

I have performed primary excision of the astragalus on four occasions for fracture by bullets, with excellent results.

(*b*) *In Fractures of the Astragalus and Malleoli combined.*—Immediate excision of the astragalus allows one in these cases to deal very sparingly with the malleoli, which is, orthopædically speaking, very important; indeed, one should never lose sight of the fact that it is far preferable to remove the astragalus and preserve the malleoli, than to sacrifice the malleoli in order to preserve the astragalus. The loss of the internal malleolus, if ankylosis of the astragalus to the bones of the leg or the newly formed periosteal bone is not obtained, is accompanied by displacement of the foot upwards and inwards; resection of the external malleolus is followed by rotation of the foot outwards, and walking is very difficult. Excision of the astragalus, on the other hand, gives a very satisfactory functional result.

FIG. 84.—Fracture of the astragalus and os calcis by a shell-splinter. Primary resection of the whole of the former and part of the latter; the posterior part of the os calcis with the insertion of the tendo Achillis was left. Orthopædic and functional result after nine months excellent. The patient had at the same time a fracture of the opposite tibia which was treated by primary sub-periosteal esquillectomy and healed without sepsis.

If, then, a missile has broken up one malleolus and has then penetrated the astragalus, this latter bone must be resected, but the treatment of the malleolar injury must be limited to clearing it out, by which means the maximum of bone and periosteum is preserved.

The excellent drainage provided by ablation of the astragalus will prevent or check the inroads of sepsis, and the malleolar fracture should run an uneventful course. The longitudinal splinters fuse together and make a rigid pillar of bone.

(*c*) *In Fractures of the Posterior Tarsus.*—When the bodies of the astragalus and os calcis are involved, when the astragalus is broken into four or five fragments and lies upon an os calcis which has been reduced to a pulp, it is necessary to abstain both from amputation of the leg, which is performed too often in these cases, and from a typical resection of the posterior tarsus.

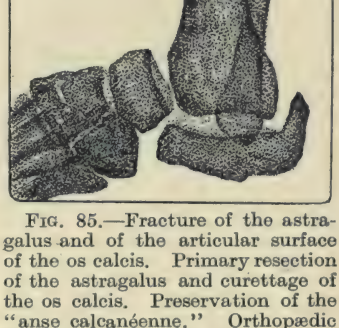

FIG. 85.—Fracture of the astragalus and of the articular surface of the os calcis. Primary resection of the astragalus and curettage of the os calcis. Preservation of the "anse calcanéenne." Orthopædic functional result after eleven months excellent.

By removing the astragalus in the first place, and then exposing the os calcis at the seat of election, enough room is obtained to scrape away completely the cancellous tissue of the os calcis, while preserving all the surrounding healthy parts which will effectually resist infection and give a solid sole capable of maintaining the shape of the foot. The clearing out of the seat of the fractures ought to be done with great attention to detail, so as to avoid the interminable suppuration which follows the retention of fragments which have been overlooked; in practice it will almost always be possible to preserve the posterior lamella of bone into which the tendo Achillis is inserted and the shell of compact bone on its plantar surface. Thus we shall have what Ollier called the "anse calcanéenne," which forms the basis of a firm periosteal

bone formation assuring perfect solidity to the foot, and enabling it to retain its normal shape. The same plan is followed with the great tuberosity, which should always be spared if possible, as it protects the articulation with the cuboid. It is most important to think out these orthopædic details before deciding to intervene in these complicated cases, for typical ablation of the os calcis is a proceeding which makes a great alteration in the support and movements of the foot, whether from the point of view of muscular action or of the movements of the anterior tarsal joints. Ollier said little on this matter. It is true, that before he would admit that the result of an ablation of the os calcis was excellent, he insisted that the patient should be able to walk without appliance and in the normal manner. The same standard should be required to-day. It is for this reason particularly that the plantar surface of the os calcis and the insertion of the tendo Achillis should be preserved. If this can be done, the result will be good in the sense that Ollier used the term, even when the injury has been very extensive. For my own part, I have obtained the best possible results from the method outlined above in cases in which the destruction of the astragalus and os calcis seemed to demand amputation of the foot with a heel flap. The procedure would be the same in injuries that extend to the fore part of the foot, but do not call for total excision of the tarsus. We shall speak of this again farther on.

3. **Amputation.**—This is only indicated if there is an insufficiency of the soft parts, especially on the sole or the heel: the injuries to the tarsal bones, however extensive they may be, ought never to cause the surgeon to amputate, if the condition of the soft parts allows any hope of the movements of the foot being eventually retained. Some means of preserving the foot can always be found, if this condition is fulfilled: excision of the astragalus combined with

esquillectomy of the bones of the leg, or with typical resection of the tibia and fibula, or total excision of the posterior tarsus, especially if performed at once, will avoid the sacrifice of the foot in what are apparently the gravest cases, even if the internal plantar vessels have been severed.

But, on the other hand, if there is not sufficient skin below and on the inner side, if the tendons are lacerated, if the posterior tibial artery and the nerves are cut, amputation low down will be better both as regards the present and the future.

Farther on we shall discuss the method of amputation that should be chosen.

III. Operative Technique

1. Modes of Access.—A precise knowledge of these is essential from the point of view of the restoration of function. *Exposure of the astragalus* ought to be made by incisions which do not sacrifice any tendon. Whether it be for removal of a foreign body or for ablation of the astragalus, the bones will be approached through the classical incisions, unless there is a special indication for using the wound of entry of the missile ; in all cases the latter will always be cleared and explored.

The classical incisions designed to avoid the tendons should be well known : there are two, an external and an internal. The foot being extended on the leg and adducted, the external and more important incision is commenced two inches above the malleolus, at the internal edge of the fibula and outside the peroneus tertius ; it runs down to the level of the cuboid in the direction of the commissure of the fourth and fifth toes ; perpendicular to it, a short incision about 1½ in. long descends to the tip of the external malleolus. The incision should be free, but not deep enough to divide the tendon of the

peroneus tertius, and especially that of the peroneus brevis below the malleolus. This incision opens the inferior tibio-fibular, the tibio-tarsal and astragalo-scaphoid articulations, and it renders easy the detachment of the anterior ligament between the fibula and the astragalus, and the clearing of the neck of the astragalus and the ligaments uniting the head of that bone to the scaphoid.

FIG. 86.—External incision for resection of the astragalus.

The second incision, antero-internal, passes round the internal malleolus and terminates a little behind its tip. From the centre of this incision, which corresponds to the base of the malleolus, another incision is made downwards and forwards as far as the level of the astragalo-scaphoid joint without going beyond the tibialis anticus tendon; this allows the tibio-tarsal and astragalo-scaphoid joints to be opened. It is unnecessary to make any posterior incisions for drainage. As soon as the incisions have been carried down to the bone, the work of the rugine should commence; it ought to be used with much care, and by its means

FIG. 87.—External elbowed incision for exposure and resection of the os calcis.

the insertions of the ligaments into the periosteum are preserved, and one does not lose one's way among the tendons and muscles. When the bone has thus been removed by means of the rugine, nothing is easier than to explore the walls of the gaping cavity.

Exposure of the Os Calcis.—The incision should be free and L-shaped, following the external border of the tendo Achillis and then the outer edge of the sole. The tendons of the peronei are drawn upwards and forwards by retractors, and in this manner enough room is obtained without endangering neighbouring tissues, so that it is easy to do all that is necessary to the os calcis. The principle underlying these operations is to do only atypical operations with the rugine and curette, sparing if possible the "anse calcanéenne," in preference to complete resections.

2. AMPUTATION.—The systematic resort to early resection much reduces the indications for amputation. Should this appear necessary, one of the four following methods should be employed, according to circumstances.

Sub-astragaloid disarticulation, which is sometimes possible when much of the plantar skin remains.

Pirogoff's amputation through the os calcis, or one of its modifications, whenever the condition of the bone will allow.

Syme's tibio-tarsal disarticulation, or that of J. Roux by an internal flap, with decortication of the os calcis by means of the rugine, so as to leave the periosteum on the shell of bone, which will form an osteo-plastic centre, as recommended by Ollier.

Guyon's supra-malleolar amputation with a posterior flap.

Amputation in the lower third of the leg.—In practice the first two forms of amputations are seldom indicated in injuries of the posterior tarsus; when a Pirogoff or a Syme is possible, excision of the posterior tarsus is generally equally so, and that operation is

always preferable. Still, whenever an amputation with a heel flap is practicable, it ought to be chosen, its functional results being so satisfactory.

If the injuries are very considerable there is no need to keep to one of the set operations and so to amputate high up the leg. Irregular atypical flaps should be cut at the level of the wound, and the bone should be sawn a little higher up than is necessary from the point of view of length of the skin flaps, since the wound must be left open and without sutures.

Sometimes sutures may be inserted after some days, but it is always necessary, in spite of this, to expect considerable retraction of the skin.

IV. Post-Operative Treatment

1. **After simple Curetting of the bone (Astragalus or Os Calcis).**—It is sufficient to place a gauze wick in contact with the bony cavity, and to immobilise the limb in good position in the simple posterior plaster splint extending above the knee, as described on page 152 ; this should be removed at each dressing, and must be remade if the plaster becomes soft. If necessary, its place may be taken by an iron wire splint. The first dressing should be left undisturbed for a week at least, if there is no rise of temperature ; then the gauze drain is abandoned, and only infrequent dressings are required. Passive movements are commenced towards the tenth day. Walking with the weight borne direct upon the ground will not be allowed for at least a month. Recovery is generally very rapid.

2. **After simple Astragalectomy.**—The joint cavity is lightly filled with aseptic gauze ; a strand of that material is introduced through each incision, so that they meet one another. It is wrong to pass a drain of this type through from one side to the other ; its removal is much more painful. It is unnecessary to insert drainage tubes. Too much dressing must not

be put on before applying the first bandage, and the dressing will not have been well applied unless the foot remains in good position, without the least tendency to displacement, when the bandage has been applied round the foot and carried up to the middle of the leg.

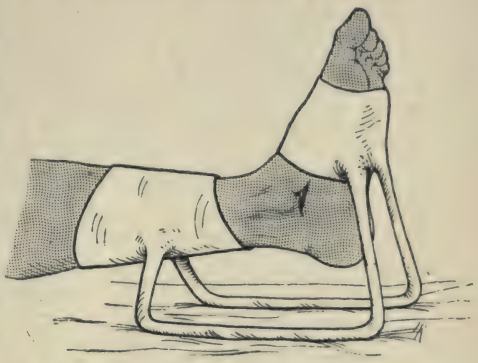

FIG. 88.—Interrupted plaster casing after resection of the astragalus.

Immobilisation will then be effected by the classical posterior plaster splint, as above. One should wait as long as possible before doing the first dressing—ten days if all goes well. If, on the first day, the blood-stained discharge has soiled all the dressings, only the superficial layers need be changed, for it is very important not to disturb the wound, and to give the tissues time and opportunity to organise their defence and commence their repair.

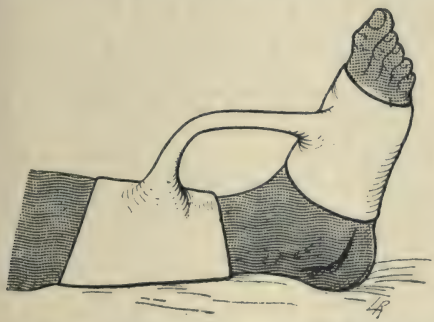

FIG. 89.—Interrupted plaster casing after resection of the os calcis.

Toward the tenth day the gauze drains are removed and replaced by others.

If any abnormal oozing necessitates frequent changes of dressings, an interrupted plaster casing must be provided, but this should not be regarded as the best apparatus since it does not immobilise well, especially at the instep, and it requires more supervision ; in short, it ought only to be used on account of free oozing, or after the ligaments round the joint have recovered their power.

This apparatus is made in the following manner : a circular bandage surrounds the lower half of the leg as far as the malleoli ; a second embraces the front half of the foot as far down as the toes. These two portions are united either by a single bracket of hoop-iron in the long axis of the leg and foot or by two of them applied laterally or else posteriorly, when they act as supports.

When the plaster is dry the heel must be carefully supported by means of a wide bandage after each dressing, and this should be converted into a sort of hammock fastened to the anterior bracket until the front part of the foot becomes fixed by its ligaments.

During the whole of the post-operative treatment constant care is required to keep the foot in correct position. If the foot rests too much on the heel, it is pushed forwards ; if it is not properly supported, it slips backwards ; if the sole is not firmly maintained in its normal position, it tends to be rotated inwards into a position of varus. Unless he is carefully watched, the patient will have a deformed foot, and it will be difficult to correct this deviation when the plaster is left off.

When a tendency to deviation is noticed, a fresh plaster casing should be applied to correct it without delay under chloride of ethyl anæsthesia. This is better than the classical traction upon the foot with an elastic bandage, which patients usually omit to use and which produces little result.

Attention should also be paid to the toes : they

should be frequently moved, to counteract stiffness, as they have a pernicious tendency to assume the shape of a plantar claw.

Walking is not allowed until the end of three months, when a plaster support is employed while waiting for the permanent support (a boot with lateral irons extending to just below the knee). There should never be any hurry in seeking for mobility, which is almost always recovered without trouble ; it should only be obtained after the parts have become firm.

The same care will be required after a typical resection of the os calcis, but the post-operative supervision should be more prolonged, and walking should only be permitted after a longer interval (four or five months).

3. **After a complex Resection.**—The line to follow is the same, but immobilisation should be of longer duration. If the malleoli have been involved in the operation, their solidification and regeneration will be a lengthy proceeding. Until the parts have become quite firm the patient must not be allowed to walk. If the parts do not become firm, it is better to try to get bony union between the os calcis and the tibio-fibular arch, if necessary by curetting the cartilage from it. This will take at least four or five months, and it must not be expected that these patients will be able to walk without a stick before eight or ten months.

It is the same in resection of the astragalus and os calcis.

4. **After Amputation.**—The operation is completed without suturing the flaps, but at the end of a few days, when there is no longer fear of infection, stitches may be inserted. One or two can be used to bring the plantar flap into apposition with the anterior surface of the leg, and in this manner the convalescence may be shortened and a better stump obtained.

V. Evacuation of Patients with Ankle Wounds

These are generally capable of speedy evacuation: a patient operated on by localised curetting of a bone can be put on the rail forty-eight hours afterwards; a resection of the astragalus, at the end of from six to eight days; a complicated resection, at the end of from ten to twelve. In cases of extreme urgency all of them can be evacuated at the end of forty-eight hours much more easily than if they had not been operated upon.

For the journey, the ideal apparatus is the posterior plaster casing, which immobilises well, does not hurt, and allows easy supervision of the toes and the leg.

VI. Treatment of Patients seen late or after Evacuation

The patient operated upon early by limited esquillectomy for injury of the bone, or by resection for an extensive fracture, heals rapidly and without incident. It is otherwise when the prophylactic operation has been omitted or has been done insufficiently.

1. A PATIENT IS SEEN AFTER A LONG INTERVAL.—A patient seen after twenty-four hours or still later, not treated at all, or insufficiently, usually shows signs of suppurative arthritis of the ankle with severe constitutional disturbance, an enormously swollen foot with livid patches up the leg, and œdema of the front of the foot and the toes. Examination is impossible as the pain is too acute. *Suppurative arthritis of the ankle* is amenable to immediate surgical measures which will probably take the form of an arthrotomy by the two exploratory incisions described above, to which should be added two counter-openings behind the malleoli for drainage between the bone and the tendo Achillis. The presence of the posterior tibial vessels on the inner side must not be forgotten.

This arthrotomy may suffice, but as we are dealing with a close-fitting joint, in which the bone is

fractured, it is safest for the present, and best for the future, to perform excision of the astragalus at once. This operation gives good drainage, and arrests the sepsis with certainty. Sometimes it has to be completed by incising purulent foci in the tendon sheaths, notably in those of the peronei. These incisions are called for if the temperature remains high after resection and there is any lateral swelling extending up the leg. At times it is necessary to carry the incision far up the leg, and it is not uncommon to see the tendinous and aponeurotic tissues slough later. Should this be the case, in order to accelerate recovery, they should be excised instead of its being left to nature to get rid of them.

It is often possible to avoid amputation, if the necessary steps are taken at once. If the gravity of the general condition or the extent of the lesions (suppuration of the whole of the foot and leg) makes amputation unavoidable, disarticulation of the foot by Syme's method or amputation of the leg should be performed ; it should not be forgotten that a plantar flap can be used, even if the section of the bone has to be carried high up (2 or 2½ inches above the external malleolus).

2. A Patient arrives with Sinuses.—These suppurating sinuses about the ankle call for excision of the astragalus, if this be the bone that is the seat of mischief. Time must not be lost in repeatedly scraping the seat of the osteitis. In a bone as badly vascularised as this and composed of a mass of cancellous tissue, osteitis spreads rapidly and involves the whole bone ; besides, the repair of a cavity scooped out with a curette cannot be effected by the sinking in of its walls. A cure is very difficult unless the entire bone be removed.

If there are sinuses leading to the os calcis, no decision should be made without radiographs ; very often indeed osteitis of this bone reaches the joint

between it and the astragalus, and usually, save when it occurs in the posterior or plantar margins, it becomes necessary, from what I have seen, to begin by removing the astragalus, in order that curettage of the os calcis may have good results. No precise rules can yet be laid down for this, but the ideas here indicated must not be lost sight of.

3. A PATIENT IS SEEN WITH A VICIOUS ANKYLOSIS, complete or otherwise, fistulous or not, the foot being fixed in equinus. If the astragalus is affected, it must not be thought that the tendo Achillis is alone at fault, and that tenotomy will suffice. Vicious ankylosis of the ankle ought to be treated by simple excision of the astragalus, which in these cases gives perfect orthopædic and functional results.

CHAPTER VIII

WOUNDS AND FRACTURES OF THE ANTERIOR TARSUS AND THE FORE-PART OF THE FOOT

I. Anatomical Types and Clinical Course

ALL the wounds of the anterior tarsus are due in practice to splinters of grenade or shell. Two factors dominate their course : the frequency of lesions involving many bones, and accordingly many joints ; and the constancy of the speedy incidence of sepsis producing diffuse suppuration of the anterior tarsus, which is too often treated by amputation, when early operations and primary resections would almost always avoid loss of the foot.

The anatomical types are very diverse, and it is dicffiult to classify them except very theoretically. We may find :

Fracture of one bone only by small splinters of shell, with the missile often remaining in a blind wound.

Oblique punctured fracture of many bones, the wound extending from the dorsum to the sole, and involving either the outer or the inner arch of the tarsus.

Punctured transverse fracture, the wound going from one edge of the foot to the other.

Complex fractures of the tarsus and metatarsus.

Complex fractures, involving the posterior tarsus.

When one bone only is affected, a localised suppurative osteitis may occur, and after the formation of an abscess a sinus may form without the inflammation

spreading to the neighbouring bones, joints, or the soft parts of the sole. But as a general rule, when a single bone is broken, there are fissures which radiate towards the contiguous bones; when several bones are fractured, although the five synovial membranes of the fore-foot may be normally independent, there is almost always a progressive invasion either of the external group, of one of the internal groups, or of the whole of the anterior tarsus. So that, in a number of cases, the anterior tarsus may be considered as one bone, articulating in front with the metatarsus, and behind with the astragalus.

When there are lesions of the metatarsus, the situation is still more complex. In the close-fitting joints between the metatarsal bones infection easily spreads in spite of any drainage, and speedily leads to septic symptoms which it is no easy matter to check, except by the complete removal of the fore-foot, or even of the entire foot.

In the fractures which extend to the posterior tarsus the position is quite as serious; the multiplicity of the folds of synovial membrane make it difficult to act to any useful purpose, while it is impossible to drain such numerous and irregularly situated cavities. The gravity of the local phenomena in all these lesions, and the intensity of the general reaction, soon demand incisions and mutilations, which an early operation would have avoided.

II. Primary Therapeutic Indications

1. **Esquillectomy, or Resection of a single Bone.**—In practice esquillectomy is almost always ablation of one of the small bones of the anterior tarsus. It is indicated when a single bone is fractured, with or without a missile *in situ*. In this case the extraction of the projectile and the early scooping out of the cavity in which it lies give excellent results.

The scaphoid, or one of the cuneiform bones, can be removed in this way, and early resection of one bone is the best means of preventing the spread of sepsis. In the case of the scaphoid in particular, the operation gives perfect results, and resection of this bone alone ought always to be practised when possible. But, if the lesion is more widespread, if many bones are involved, or many synovial membranes are opened, there must be no hesitation in completely scraping out the bones affected, however atypical the operation may be.

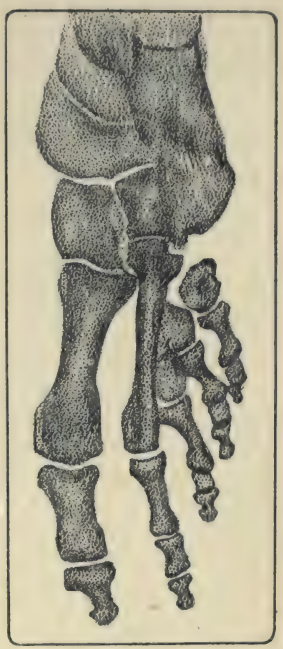

FIG. 90.—Sub-periosteal resection of the cuboid and of the third cuneiform with subtotal resection of the last three metatarsals. Orthopædic result excellent. The officer upon whom this operation was performed has been able to rejoin an Alpine battalion. This radiograph was taken on the occasion of a second wound seven months after the first.

It is important that this should be carried out everywhere in healthy tissues and with free incisions, without which atypical operations become dangerous. There is, however, a limit to this lateral loss of tissue ; when more than a third of the total width of the tarsus becomes involved in these resections, the orthopædic result will be unsatisfactory. The lateral loss of tissue cannot be filled up with firm new growth. The corresponding metatarsal bones are gradually displaced, at first backwards and then inclining laterally; adjacent metatarsal bones

become deflected at the point of their attachment to the tarsus.

This causes secondary varus or vulgus, with painful deformity of the sound side of the foot or of the sole. That is why Ollier decided on orthopædic grounds in favour of total excision of the anterior tarsus, whenever it is impossible to leave intact rather more than one-half of the width of the tarsus.

Good results may nevertheless be got by getting rid of the metatarsals corresponding to the damaged bones, especially if they are injured. The functional result of this excision of tarsus and metatarsus is good, but its appearance is deplorable.

2. **Resection of the Anterior Tarsus.**—When many bones are fractured, especially in the transverse direction, one must consider the necessity of an extensive operation. If the injuries exceed one-third of its width, the tarsus should be treated as if it consisted of a single bone with a wide periosteal covering reinforced by numerous and firm ligaments, and having only two articular surfaces, in front, the cartilaginous surface of Lisfranc's joint (the junction of the tarsus with the metatarsus), and behind, the head of the astragalus. The entire anterior tarsus should then be removed by sub-periosteal resection. If, however, the scaphoid is healthy, it should be left in place, and no more will be done than ablation of the three cuneiforms and the cuboid ; a partial operation which is followed by slight valgus, but which allows the patient to walk excellently, and is quite commendable.

These different indications may appear a little theoretical, and certain surgeons think they need not be taken into account. Satisfied with the immediate result, they imagine that the orthopædic result is one in which they have no further interest, since they suppose, from want of experience, that it will be all they desire. The observation of end-results would quickly undeceive them. But it is not necessary to

be eternally repeating the experiences of the past; the end-results of these operations have been clearly ascertained in times of peace, and orthopædic principles are not changed by the nature of the injuries.

When fractures of the tarsus are complicated with radiating fissures extending to the metatarsus, the opportunity arises to combine esquillectomy of the metatarsals with the tarsal operations. If a partial operation is decided upon, the metatarsal bones should not be interfered with more than is strictly necessary. If, on the other hand, resection of the anterior tarsus is deemed advisable, the line of the tarso-metatarsal articulation must be considered as if the metatarsus were a single bone, and a flush line of section made with the saw.

3. **Excision of the Tarsus (Total or Subtotal).**—When there is a fracture of the bones of the anterior tarsus, and the astragalus, or the os calcis, or both of them, are involved, early intervention is more pressing than ever. A smash of the tarsus is indeed perfectly amenable to a conservative operation, but it must be primary, and the surgeon must not wait for the occurrence of diffuse suppuration before acting. There will be no question of absolutely typical operations, but one must be directed by the principles governing a typical resection, and must recognise that in total excision of the tarsus one has a marvellous means of avoiding amputation. In this proceeding, the fractured tarsus is to be considered as formed of one single bone, reinforced by firm ligaments, and as having only two articulations, a tibio-tarsal and a tarso-metatarsal. When this tarsal mass has been removed by the sub-periosteal method, there remains what Ollier calls a "suro-metatarsal" cuff, which unites the bones of the leg with the posterior extremities of the metatarsals. Behind, the insertion of the tendo Achillis strengthens it; below, there are the ligaments between the cuboid and os calcis; at the sides,

the ligaments between the tarsus and the tibia and fibula. This sheath is very resistent, and when, thanks to the periosteum, new osseous plaques are formed in it, it is able to recover sufficient strength to support the weight of the body and to connect the metatarsus closely with the bones of the leg.

There is a further reason for this operation after destruction of the tarsus by gun-shot wounds. In these cases certain healthy tissues can be preserved, such as the posterior and inferior part of the os calcis, and in these circumstances the orthopædic results will be even better. Atypical clearing out of the space between the tibia and the metatarsus ought to be practised whenever the condition of the soft parts allows, and if, while preserving the periosteum and the healthy bone, one is careful to leave no irregular surfaces, with diverticula which it is difficult to drain, many amputations will be avoided.

4. **Amputation.**—Primary amputation is rendered necessary, rather by the extent of the injury to the soft parts, than by the damage to the bone strictly speaking; in excision of the tarsus, typical or atypical, one can always deal with the tarsus, however extensively destroyed. But if the skin is torn and the tendons are hopelessly damaged, this fundamental idea should be our guide: when dealing with the foot, it is necessary before all things to try to obtain a solid and painless support for walking and for standing.

Consequently, when the destruction of the soft parts is too extensive to allow one to hope for a cicatrix capable of bearing pressure, amputation should be performed at once, but amputation of the leg must be avoided if possible. If the fore-foot and the anterior tarsus are crushed, Chopart's disarticulation will not generally be adopted, or indeed any other measure of this kind; the necessary material for the typical flaps will always be wanting. It will be better to limit

oneself to a level section, and to try later to form a permanent flap. The skin is divided at the level of the contused tissues either on the dorsum or the sole of the foot, keeping as much of the tissues of the foot as possible without disarticulating, but proceeding, so to speak, as in esquillectomy. At a later date, sometimes quite soon if sepsis does not supervene, secondary sutures can be put in and a suitable stump formed : in a case of this kind with multiple fractures, I was able subsequently to cover over the scaphoid and the cuboid, when a typical primary operation would certainly have driven me to disarticulation at the tibio-tarsal joint.

Must Chopart's operation be condemned when there is sufficient material ? One always blames that operation for the "tilted" fully extended stump, which makes the patient walk upon the tuberosity of the os calcis, or even on the head of the astragalus ; and Tuffier does not advise the operation, which has often given, he says, stumps that cannot be used. I have had no personal experience of it, never having performed medio-tarsal disarticulation, but I have seen some patients upon whom it had been done by Bérard, who walked very well. In short, when there is enough skin, Chopart's operation is legitimate, but only in very favourable cases. That is as good as saying that the indications for its adoption will be few.

If the lesions of the soft parts are more extensive, the surgeon will disarticulate at the tibio-tarsal joint, with or without section of the os calcis.

Three types of operation are possible :

Syme's disarticulation with sub-periosteal decortication of the os calcis after the method of Ollier.

Pirogoff's tibio-tarsal disarticulation with oblique section of the os calcis.

Guyon's supra-malleolar amputation.

To sum up : curetting, or resection of a single bone, in cases of limited injury ; partial resection, if the

damage does not extend over more than one-third of the width of the fore-foot; anterior tarsectomy, if the lesions are more extensive; atypical total tarsectomy, if the injuries affect the posterior tarsus; amputation through the tarsus or os calcis, or above the malleoli, if the soft parts are gone, and if the foot is destroyed.

III. Operative Technique

All the operations on the anterior tarsus ought to be done with the rugine, strictly sub-periosteally, without dividing any tendons in the incisions.

1. Esquillectomy, or Resection of a single Bone.—An incision is made over the orifice of entry of the missile, and when the perforated bone is reached, it is cleared out with a curette. If the injury is slight, the procedure will cease when the missile has been removed; but if the clearing-out process leaves any loose cartilaginous fragments, it is better to remove the bone entirely.

Fig. 91. — The different incisions for use in anterior resection of the tarsus.

2. Resection of the Anterior Tarsus.—The regular ablation of the bones of the tarsus is done according to the indications of Ollier, by means of three or four incisions parallel with the long axis of the foot, so as to sacrifice neither tendons, muscles, vessels, nor nerves. One commences on the side of the foot at which the injuries are most extensive, for example the internal edge.

The first incision will be at this level. It will commence a little behind the tubercle of the scaphoid and will extend down just beyond the joint between the

first metatarsal and the internal cuneiform. The periosteo-capsular sheath will be incised along the lower edge of the bones, whatever injury they may have sustained. A point at which the periosteum and the ligaments are sound is chosen as a starting-point for the detachment, and this is done as completely as possible, passing below the tendon of the tibialis posticus, and following along the abductor hallucis.

The second incision is made along the outer edge of the extensor proprius hallucis, in order to avoid the dorsalis pedis artery which is slightly to its outer side. The periosteo-capsular sheath is opened along the outer edge of the internal cuneiform.

The third incision corresponds with the joint between the cuboid and the external cuneiform, and passes between the fourth and fifth extensor tendons.

The fourth incision lies over the outer border of the cuboid. It follows the upper edge of the peroneus brevis tendon.

This is all no doubt very diagrammatic, and often the extent of the lesions will not permit so rigorous a technique. But the spirit rather than the letter should be followed ; the object is not to divide tendons, but still to have enough room to remove the bones easily. No fractured bone should be forcibly torn out ; it is no advantage to sever with the bistoury the ligaments which fix it in place. Ablation should be effected with the sharp rugine and the ligaments should be preserved as far as possible.

When all the bones are removed, the line of the articular surface of the metatarsus is a somewhat irregular one ; likewise, posteriorly, where the head of the astragalus stands out, as does the second metatarsal in the joint (*i.e.* tarso-metatarsal) of Lisfranc. It is unnecessary to make these surfaces flush ; the periosteum, which has been preserved, levels all inequalities and assures juxtaposition of the astragalus and metatarsus.

After the operation all the incisions are left open, and a gauze drain is placed transversely at the level of the anterior astragalo-calcanean joint.

3. Total Tarsectomy.—This operation, if performed methodically, allows feet to be preserved which have had their bony tissues completely destroyed. The operation sacrifices the bones of the anterior tarsus and the astragalus, which ought always to be completely removed, but it rigidly preserves the inferior surface and the tuberosities of the os calcis. It can easily be done by means of the incisions for excision of the astragalus combined with the dorsal incisions described above for excision of the anterior tarsus. The entire operation should be rigidly sub-periosteal, so as to preserve as much tissue as possible for padding to fill up the immense cavity left by the operation.

4. Amputation.—The discussion of the various types of amputation already given (page 193) furnishes technical indications for the choice of any particular method according to the case under observation. As to actual points of technique, we need give only the following details :

The transverse incision of Syme is excellent, whenever it is possible. If an osteoplastic amputation is done, it is not necessary to follow the classical rules. The exact extent of the bone-section will vary with the dimensions of the flap available. If ample soft parts are at hand, a typical Pirogoff may be done or the cut surface of the os calcis may be trimmed so as to adapt it to the tibio-fibular arch which is not then resected (Quénu), especially if it is essential to gain time.

If it is necessary to remove the os calcis, decortication of that bone should be done with the rugine, according to the practice of Ollier. The advantage of this is that the flap is thicker, better nourished, and better padded, and finally becomes furnished with an

osteo-fibrous core. It is also easier to do, and the end-result is far preferable.

The heel flap, lined with periosteum, can be used even when as much as four inches of the bones of the leg must be sacrificed. The stump left is no doubt irregular and awkward; but it gradually adapts itself, and in the end the functional result is excellent.

FIG. 92.—Disarticulation of the foot by Syme's operation, without cutting through the malleoli. Walking is easy and painless with an improvised apparatus. The change effected in eight months in the tibio-tarsal articular surface is noticeable.

After disarticulation of the foot, it is unnecessary to resect the tibial surface and remove the malleoli. It is customary to do this in operative surgery on the cadaver, but it presents no practical utility. I have seen a patient eight months after a disarticulation in which I had left the malleoli; he walked very well, without pain, and with a boot improvised by himself.

After typical tibio-tarsal disarticulation, it is found advisable as a preventive measure to divide the tendo Achillis. Since primary suture of the anterior and posterior tendons and of the skin flaps cannot and ought not to be done in these cases, the stump would be likely to retract under the pull of the soleus and gastrocnemius. Open section of the tendo Achillis will prevent this; the tenotomy wound can be used

for drainage, and has the advantage that it is at the lowest point.

After the operation, a gauze drain is inserted after the flap has been fastened in place by one or two anterior sutures; a few other temporary sutures are inserted at the angles. On each side a drain of gauze is slipped into the cavity of the heel, which always oozes. These drains are removed at the first dressing, and if all goes well, the temporary stitches are tied.

IV. Post-Operative Treatment

This is practically identical with that for operations for injuries of the ankle.

1. After Partial Resection of the Anterior Tarsus.—The foot is rigidly immobilised in a plaster casing which supports the toes and extends above the knee. The dressing must be done at long intervals, so as to secure immobilisation for a very long time, even after cicatrisation; this is necessary to overcome the traction of the scar-tissue, which tends to cause deviation of the front of the foot. One must bear in mind the frequency of the various deformities which follow this retraction and the dislocation of the foot which may result from the changes which the normal supporting surfaces of the sole have undergone. Later on, if it is not guarded against, there will be a deviation of the bones and projections which will compress the nerves in the sole and cause painful pressure. Before the war late amputations had to be done, because of the painful and troublesome deformity. The process of periosteal repair must therefore be aided by maintaining the foot for a long time in a normal position. Walking will only be allowed some considerable time after cicatrisation has occurred, and then only with an orthopædic boot. It might be worth trying to remedy the defects remaining by the help of grafts of cartilage.

2. After Total Anterior Tarsectomy.—After drainage has been established as has been described above, and the incisions have been plugged with gauze, the foot is immobilised in the usual posterior plaster casing. The first dressing is delayed as long as possible, at least eight to ten days, if there is no rise of temperature. It will then be found that the soft parts have come together to a considerable degree, giving to the foot a peculiar shape so characteristic that it cannot be mistaken for any other condition: the plantar arch has become convex; it is what Ollier has called the "skate-shaped" foot. There is no need to be anxious. This deformity is due to the action of the muscles of the leg, the os calcis being tilted by the tendo Achillis, whilst the anterior segment of the foot tilts in the opposite direction under the action of the extensors of the toes. Little by little the projection decreases, as cicatrisation takes place, and the final result is good. Walking ought not to be permitted before three or four months.

3. After Tarsectomy, Total or Complex.—The foot is immobilised, as usual, in the posterior plaster casing extending up above the knee. This is removed at each dressing, an assistant holding the forefoot with one hand, and the leg with the other. After some time the first plaster casing will have become too large, and a properly fitting one is substituted.

The course of the case is generally uneventful, and complete recovery requires from five to six months. Walking with the weight borne direct upon the sole is not allowed before that time.

4. After Amputation or Disarticulation of the Foot.—No special care is necessary, except after Syme's operation; in the latter, if the temperature is raised, or there are symptoms of local infection, retention of the discharges in the hollow of the heel may be suspected. The best way of checking it is to remove the stitches and let the flap hang widely open.

Afterwards it will be supported and held in place by bandages, which generally suffice to secure satisfactory healing with the flap in the right position.

V. Evacuation of Patients with Anterior Tarsal Wounds

These patients can be sent away shortly after the primary operation has been performed. After resection of one bone, or after extraction of a missile, a patient can be evacuated at the end of forty-eight hours. An anterior tarsectomy ought to be kept for from six to eight days, a total tarsectomy from twelve to fifteen days. In case of necessity, all of these could be evacuated early, much more easily than if they had not been operated upon.

The journey should not exceed twenty-four hours by rail.

The ideal apparatus for travel is the posterior plaster casing.

VI. Treatment of Patients seen late or after Evacuation

1. A PATIENT IS SEEN WITH ACTIVE SEPSIS.—If he has been insufficiently operated upon, or not incised, three different conditions may be present :

(*a*) *If it is a blind wound*, caused by a shell-splinter which has not been removed and has caused great damage, there is limited sepsis of the foot with more or less extensive pockets of pus. The necessary incisions will be made, so as to check the acute symptoms and remove the missile, the decision as to which is the best operation for the bone and joint, whether ablation of the bone, scraping out, or typical resection, being reserved for a later date ; this will be made according to the indications from the orthopædic point of view, which are explained above.

(*b*) *If it is a wound penetrating the bone*, the skin

wounds being ragged but not extensive, the case is one of suppurative osteo-arthritis, which is manifested by severe constitutional disturbance, high temperature, and a serious local condition. The whole of the dorsum of the foot as far as the tibio-tarsal joint is swollen and œdematous, with livid patches. From the orifices of entry and exit exudes a turbid discharge. Sometimes the lesion is indolent, and arthritis develops without

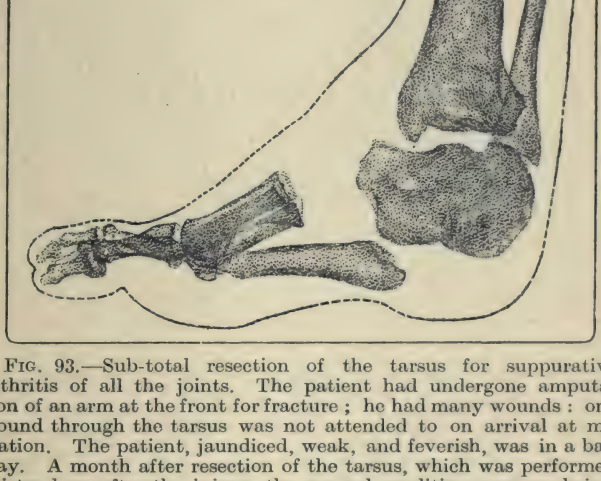

FIG. 93.—Sub-total resection of the tarsus for suppurative arthritis of all the joints. The patient had undergone amputation of an arm at the front for fracture ; he had many wounds : one wound through the tarsus was not attended to on arrival at my station. The patient, jaundiced, weak, and feverish, was in a bad way. A month after resection of the tarsus, which was performed thirty days after the injury, the general condition was much improved and the foot on the way to cicatrisation. Radiograph taken eight days after operation.

much reaction, but the condition is quite as severe. Still, there is no reason to consider that amputation is inevitable.

After radiography, resection should be at once resorted to ; it should be either total anterior tarsectomy, or a complex tarsectomy, sacrificing as much bone as is necessary to obtain a cavity with walls which

are smooth, clean, and free from diverticula. This will often lead to removal of the astragalus as well as the whole of the anterior tarsus, or even most of the os calcis. Any cavity and all pockets of pus must be opened freely. In one case of this kind I only left the os calcis and four of the metatarsals, and even three of these were sawn through just beyond their bases. It might perhaps be objected that disarticulation of the foot would have been better, but such is not the case: the immediate and future results of these operations are excellent, when the operation has been correctly performed, and when the post-operative treatment is suitably attended to.

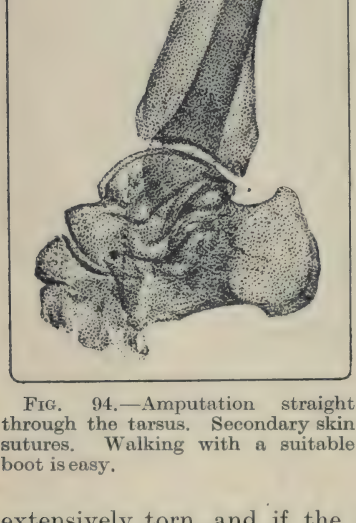

FIG. 94.—Amputation straight through the tarsus. Secondary skin sutures. Walking with a suitable boot is easy.

If the foot is no more than a bag of pus, if the tendons are extensively torn, and if the constitutional condition is serious, without question the decision will be in favour of amputation. When the injury involves the tarsus and metatarsus, amputation will be done by a level section, according to Quénu's advice, through the middle of the tarsus, at the level of the seat of injury, without troubling about the lines of the joints unless the extent of the plantar skin allows of a typical disarticulation. In any case the wound will be dressed wide open and the plastic covering-in will only be done later.

When, on the contrary, a wound of the anterior tarsus is in question, the best operation is disarticulation of the foot, with section of the os calcis, or the Syme-Ollier operation.

If the posterior tarsus is affected, the foot should be disarticulated, or a supra-malleolar amputation done with a heel flap, or Guyon's posterior flap.

The wound is left largely open; the flaps will only be kept together by one or two sutures for the time being.

If the wound is on the surface, and if there has been much laceration of the skin, with loss of muscles and tendons and absence of the soft parts, the septic condition is less grave, but the decision as to the operation most suitable is perhaps still more difficult. When a certain amount of skin has been lost, resection is still possible; in other cases, amputation becomes necessary. It is impossible to lay down fixed rules; it is a question of degree, and a matter for surgical experience. As a general rule, it is best not to sacrifice anything at first.

2. A Patient is seen with Sinuses.—Unless the injury is very limited, as demonstrated by radiography, a minor operation is not much use; resection is often necessary, and it will be better to do it early, according to the severity of the lesions. In certain cases, disarticulation at the tibio-tarsal joint or amputation through the os calcis is called for.

3. A Patient is seen with a Deformity of the foot which prevents him from walking.—A typical resection may be tried, in default of which, the only resort will be amputation (Syme's or Pirogoff's).

CHAPTER IX

MULTIPLE JOINT WOUNDS

One frequently observes multiple articular wounds caused either by machine-gun wounds or by shell splinters. Every possible combination is seen, of which the most frequent appear to be wounds of the shoulder and elbow of the same arm, and those of both knees. When this is the case, the customary rule of systematic operative prophylaxis should be more absolute and imperative than ever; any wound near a joint, however small it may be, should not be neglected, even if some other serious accompanying wound appears to demand exclusive attention. This is the only way to avoid cruel disappointments.

An exploratory incision should be made for each joint injured, and the operation se-

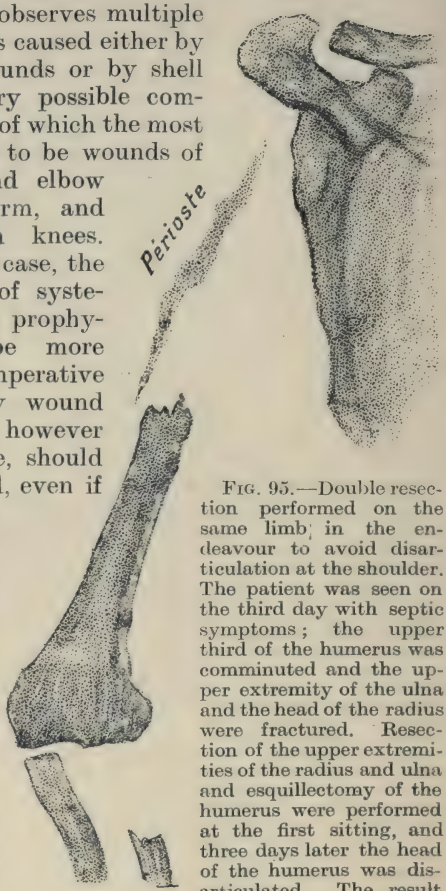

Fig. 95.—Double resection performed on the same limb in the endeavour to avoid disarticulation at the shoulder. The patient was seen on the third day with septic symptoms; the upper third of the humerus was comminuted and the upper extremity of the ulna and the head of the radius were fractured. Resection of the upper extremities of the radius and ulna and esquillectomy of the humerus were performed at the first sitting, and three days later the head of the humerus was disarticulated. The result at the end of six months was as indicated in figs. 96 and 97.

lected will be that which is demanded by what is found: exploratory arthrotomy with simple extraction of the missile if there is no fracture, or with limited sub-periosteal esquillectomy if a slight parietal fracture is encountered; resection in any other case. In short, each articular lesion will be treated as if it existed alone.

In cases of doubt the most radical means should be

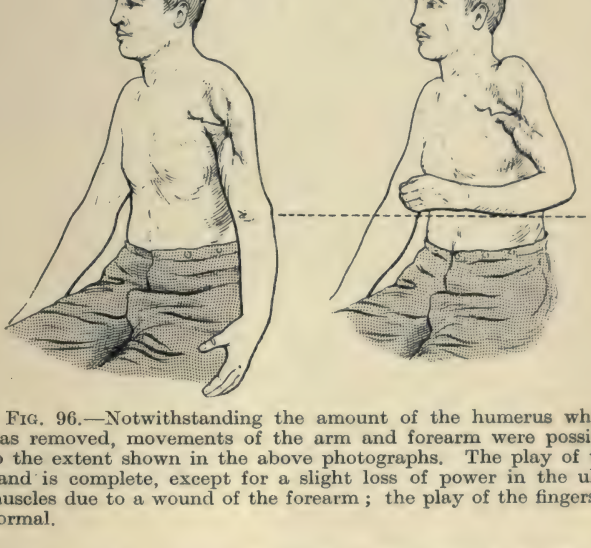

FIG. 96.—Notwithstanding the amount of the humerus which was removed, movements of the arm and forearm were possible to the extent shown in the above photographs. The play of the hand is complete, except for a slight loss of power in the ulna muscles due to a wound of the forearm; the play of the fingers is normal.

chosen. For example, resection should be done in preference to esquillectomy, or amputation in preference to resection, if either of the latter appears at all hazardous.

Sometimes in this way one will be led to do two resections upon the same limb; Gayet has reported a case of resection of the knee and of the astragalus

of the same side. I myself have done, on the same limb, a very extensive double resection of the shoulder and a resection limited to the extremities of the forearm at the elbow, with an excellent result. The wounded man, who has lost more than one-third of the humerus, easily contracts his shoulder muscles in order to draw up the remainder of his humerus,

FIG. 97.—Drapier's apparatus taking the place of the humerus which has been removed and permitting very satisfactory movements of the upper limb.

and to give a solid fulcrum to the flexors of his forearm. This done, he is able, without any appliance, to bring his forearm, with some energy, to more than a right angle. With an apparatus, the function of the limb is very satisfactory, and the hand very useful. Double resection has certainly avoided amputation in this case, which was operated upon when sepsis was in full

swing and the general and local phenomena were grave. It may be added that he had several other wounds of the skull and the face.

In another patient I did an arthrotomy for extraction at the knee and a resection of the shoulder and another of the elbow, with good functional results.

It is seen, then, that even with very extensive multiple injuries, conservative surgery has its indications and its efficacy, but it is of importance to act more rapidly than ever, and to use complete operative prophylaxis against infection for even the slightest wound.

To sum up: in the most complex cases, it is at once necessary and sufficient to apply this fundamental precept of military surgery, which is at the same time the cardinal principle of conservative surgery as applied to joints.

PRINTED IN GREAT BRITAIN
BY HAZELL, WATSON AND VINEY, LD.,
LONDON AND AYLESBURY.

THE UNIVERSITY OF LONDON PRESS, LTD.
have pleasure in announcing the publication of the following series which covers the whole field of War Medicine and Surgery

MILITARY MEDICAL MANUALS.

A Series of handy and profusely illustrated manuals translated from the French under the general Editorship of

SIR ALFRED KEOGH,

G.C.B., LL.D., M.D., F.R.C.P., Hon. F.R.C.S.
Late Director-General Army Medical Service

AND

Lt.-Gen. T. H. J. C. GOODWIN

C.B., C.M.G., D.S.O.
Director-General Army Medical Service

Each translation has been made by a practised hand and is edited by a specialist in the branch of surgery or medicine covered by the volume. It was felt to be a matter of urgent necessity to place in the hands of the medical profession a record of the new work and new discoveries which the war has produced, and to provide for everyday use a series of brief and handy monographs of a practical nature. The present series is the result of this aim. Each monograph covers one of the many questions at present of surpassing interest to the medical world, is written by a specialist who has himself been in close touch with the progress which he records in the medicine and surgery of the war. Each volume of the series is complete in itself, while the whole will form a comprehensive picture of the medicine and surgery of the Great War.

From the BRITISH MEDICAL JOURNAL: "The books are short and practical, and are founded upon the most recent clinical and laboratory experience."

THE TREATMENT OF INFECTED WOUNDS. By A. Carrel and G. Dehelly. Translated by Herbert Child, Capt. R.A.M.C., with Introduction by Sir Anthony A. Bowlby, K.C.M.G., K.C.V.O., F.R.C.S., Surgeon-General Army Medical Service. With 97 illustrations in the text and six plates. Second Edition, with additions. **Price 6/- net**

Is as fine an example of correlated work on the part of the chemist, the bacteriologist, and the clinician as could well be wished for, and bids fair to become epoch-making in the treatment of septic wounds.

The cost of postage per volume is: Inland 3d.; Abroad 8d.

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

MILITARY MEDICAL MANUALS

THE SPECTATOR: "It would be hard to imagine a better set of books; they are well written, well translated, well illustrated, moderate in length, and moderate in price."

THE PSYCHONEUROSES OF WAR. By Dr. G. Roussy, Assistant Professor in the Faculty of Medicine, Paris, and J. Lhermitte, sometime Laboratory Director in the Faculty of Medicine, Paris. Edited by Colonel William Aldren Turner, C.B., M.D., and Consulting Neurologist to the Forces in England. Translated by Wilfred B. Christopherson. With 13 full-page plates. Price 6/- net

"The Psychoneuroses of War" being a book which is addressed to the clinician, the authors have endeavoured, before all else, to present an exact semeiology, and to give their work a didactic character. After describing the general idea of the psychoneuroses and the methods by which they are produced, the authors survey the various clinical disorders which have been observed during the war.

THE CLINICAL FORMS OF NERVE LESIONS (Vol. I). By Mme. Athanassio Benisty, House Physician of the Hospitals of Paris (Salpêtrière), with a Preface by Professor Pierre Marie. Edited with a Preface by E. Farquhar Buzzard, M.D., F.R.C.P., Captain R.A.M.C.(T.), etc. With 81 illustrations in the text, and seven full-page plates. Price 6/- net

In this volume will be found described some of the most recent acquisitions to our knowledge of the neurology of war. But its principal aim is to initiate the medical man who is not a specialist into the examination of nerve injuries. He will quickly learn how to recognise the nervous territory affected, and the development of the various clinical features; he will be in a position to pronounce a precise diagnosis, and to foresee the consequences of this or that lesion.

THE TREATMENT AND REPAIR OF NERVE LESIONS (Vol. II). By Mme. Athanassio Benisty. Edited by E. Farquhar Buzzard, M.D., F.R.C.P., Capt. R.A.M.C.(T.), etc. With 62 illustrations in the text and four full-page plates. Price 6/- net

This volume is the necessary complement of the first. It explains the nature of the lesions, their mode of repair, their prognosis, and above all their *treatment*. It provides a series of particularly useful data as to the evolution of nerve-wounds—the opportunities of intervention—and the prognosis of immediate complications or late sequelae.

The cost of postage per volume is: Inland **5d.** *; Abroad* **8d.**

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

MILITARY MEDICAL MANUALS

"The importance of this comprehensive series can hardly be exaggerated. The French genius in its application to scientific medicine will be discovered here at its best and it will be found to be a distinct gain to have had this method of collaboration applied to so important an enterprise."

THE TREATMENT OF FRACTURES. By R. Leriche, Assistant Professor in the Faculty of Medicine, Lyons. Edited by F. F. Burghard, C.B., M.S., F.R.C.S., formerly Consulting Surgeon to the Forces in France. Vol. I.—"Fractures Involving Joints." With 97 illustrations from original and specially prepared drawings. Price 6/- net

The author's primary object has been to produce a handbook of *surgical therapeutics*. But surgical therapeutics does not mean merely the technique of operation. Technique is, and should be, only a part of surgery, especially at the present time. The purely operative surgeon is a very incomplete surgeon in time of peace; "in time of war he becomes a public disaster; for operation is only the first act of the first dressing."

Vol. II.—"Fractures of the Shaft." With 156 illustrations from original and specially prepared drawings. Price 6/- net

Vol. I. of this work was devoted to *Fractures Involving Joints*; Vol. II. (which completes the work) treats of *Fractures of the Shaft*, and is conceived in the same spirit—that is, with a view to the production of a work on *conservative surgical therapeutics*.
The author strives on every page to develop the idea that anatomical conservation must not be confounded with functional conservation. The two things are not so closely allied as is supposed. There is no conservative surgery save where the function is conserved. The essential point of the treatment of diaphysial fractures consists in the early operative disinfection, primary or secondary, by an extensive sub-periosteal removal of fragments, based on exact physiological knowledge, and in conformity with the general method of treating wounds by excision. When this operation has been carefully performed with the aid of the rugine, with the object of separating and retaining the periosteum of all that the surgeon considers should be removed, the fracture must be correctly reduced and the limb immobilised.

FRACTURE OF THE LOWER JAW. By L. Imbert, National Correspondent of the Société de Chirurgie, and Pierre Réal, Dentist to the Hospitals of Paris. With a Preface by Medical Inspector-General Février. Edited by J. F. Colyer, F.R.C.S., L.R.C.P., L.D.S. With 97 illustrations in the text and five full-page plates. Price 6/- net

Previous to the present war no stomatologist or surgeon possessed any very extensive experience of this subject. Claude Martin, of Lyons, who perhaps gave more attention to it than anyone else, aimed particularly at the restoration of the occlusion of teeth, even at the risk of obtaining only fibrous union of the jaw. The authors of the present volume take the contrary view, maintaining the consolidation of the fracture is above all the result to be attained. The authors give a clear account of the various displacements met with in gunshot injuries of the jaw and of the methods of treatment adopted, the latter being very fully illustrated.

The cost of postage per volume is: Inland **5d.**; *Abroad* **8d.**

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

MILITARY MEDICAL MANUALS

THE SPECTATOR: "For our physicians and surgeons on active service abroad or in military hospitals at home these are the very books for them to dip into, if not to read through."

FRACTURES OF THE ORBIT AND INJURIES OF THE EYE IN WAR. By Felix Lagrange, Professor in the Faculty of Medicine, Bordeaux. Translated by Herbert Child, Captain R.A.M.C. Edited by J. Herbert Parsons, D.Sc., F.R.C.S., Temp. Captain R.A.M.C. With 77 illustrations in the text and six full-page plates.

Price 6/- net

Grounding his remarks on a considerable number of observations, Professor Lagrange arrives at certain conclusions which at many points contradict or complete what we have hitherto believed concerning the fractures of the orbit: for instance, that traumatisms of the skull caused by fire-arms produce, on the vault of the orbit, neither fractures by irradiation nor independent fractures; that serious lesions of the eye may often occur when the projectile has passed at some distance from it. There are, moreover, between the seat of these lesions (due to concussion or contact) on the one hand, and the course of the projectile on the other hand, constant relations which are veritable clinical *laws*, the exposition of which is a highly original feature in this volume.

HYSTERIA OR PITHIATISM, AND REFLEX NERVOUS DISORDERS. By J. Babinski, Member of the French Academy of Medicine, and J. Froment, Assistant Professor and Physician to the Hospitals of Lyons. Edited with a Preface by E. Farquhar Buzzard, M.D., F.R.C.P., Captain R.A.M.C.(T.), etc. With 37 illustrations in the text and eight full-page plates. Price 6/- net

The number of soldiers affected by hysterical disorders is great, and many of them have been immobilized for months in hospital, in the absence of a correct diagnosis and the application of a treatment appropriate to their case. A precise, thoroughly documented work on hysteria, based on the numerous cases observed during two years of war, was therefore a necessity under present conditions. Moreover, it was desirable, after the discussions and the polemics of which this question has been the subject, to inquire whether we ought to return to the old conception, or whether, on the other hand, we might not finally adopt the modern conception which refers hysteria to pithiatism.

WOUNDS OF THE SKULL AND THE BRAIN. Clinical forms and medico-surgical treatment. By C. Chatelin and T. De Martel. With a Preface by the Professor Pierre Marie. Edited by F. F. Burghard, C.B., M.S., F.R.C.S., formerly Consulting Surgeon to the Forces in France. With 97 illustrations in the text and two full-page plates. Price 7/6 net

Of all the medical works which have appeared during the war, this is certainly one of the most original, both in form and in matter. It is, at all events, one of the most individual. The authors have preferred to give only the results of their own experience, and if their conclusions are not always in conformity with those generally accepted, this, as Professor Pierre Marie states in his preface, is because important advances have been made during the last two years; and of this the publication of this volume is the best evidence.

The cost of postage per volume is: Inland **5d.**; *Abroad* **8d.**

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

MILITARY MEDICAL MANUALS

From THE TIMES: "A series of really first-rate manuals of medicine and surgery . . . . the translations are admirably made. They give us in English that clearness of thought and that purity of style which are so delightful in French medical literature and are as good in form as in substance."

LOCALISATION AND EXTRACTION OF PROJECTILES. By Assistant Professor Ombrédanne, of the Faculty of Medicine, Paris, and M. Ledoux-Lebard, Director of the Laboratory of Radiology of the Hospitals of Paris. Edited by A. D. Reid, C.M.G., M.R.C.S., L.R.C.P., Major (Temp.) R.A.M.C. With a Preface on Extraction of the Globe of the Eye, by Colonel W. T. Lister, C.M.G.. With 225 illustrations in the text and 30 full-page photographs. Price 10/6 net

This volume appeals to surgeons no less than to radiologists. It is a summary and statement of all the progress effected by surgery during the last two and a half years. MM. Ombrédanne and Ledoux-Lebard have not, however, attempted to describe all the methods in use, whether old or new. They have rightly preferred to make a critical selection, and—after an exposition of all the indispensable principles of radiological physics—they examine, in detail, all those methods which are typical, convenient, exact, rapid, or interesting by reason of their originality: the technique of localisation, the compass, and various adjustments and forms of apparatus.

WOUNDS OF THE ABDOMEN. By G. Abadie (of Oran), National Correspondent of the Société de Chirurgie. With a Preface by Dr. J. L. Faure. Edited by Sir Arbuthnot Lane, Bart., C.B., M.S., Colonel (Temp.), Consulting Surgeon to the Forces in England. With 67 illustrations in the text and four full-page plates. Price 7/6 net

Dr. Abadie has been enabled, at all the stations of the army service departments, to weigh the value of methods and results, and considers the following problems in this volume: (1) How to decide *what is the best treatment* in the case of penetrating wounds of the abdomen; (2) How to instal the *material organisation* which permits of the application of this treatment, and how to recognise those conditions which prevent its application; (3) How to decide *exactly what to do in each special* case—whether one should perform a radical operation, or a palliative operation, or whether one should resort to medical treatment.

WOUNDS OF THE BLOOD-VESSELS. By L. Sencert, Assistant Professor in the Faculty of Medicine, Nancy. Edited by F. F. Burghard, C.B., M.S., F.R.C.S., formerly Consulting Surgeon to the Forces in France. With 68 illustrations in the text and two full-page plates. Price 6/- net

Hospital practice had long familiarised us with the vascular wounds of civil practice, and the experiments of the Val-de-Grâce School of Medicine had shown us what the wounds of the blood-vessels caused by modern projectiles would be in the next war. But in 1914 these data lacked the ratification of extensive practice. Two years have elapsed, and we have henceforth solid foundations on which to establish our treatment. In a first part, Professor Sencert examines the wounds of the great vessels in general; in a second part he rapidly surveys the wounds of vascular trunks in particular, insisting on the problems of operation to which they give rise.

The cost of postage per volume is: Inland 8d.; *Abroad* 8d.

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

MILITARY MEDICAL MANUALS

GLASGOW HERALD: "The whole series is heartily commended to the attention and study of all who are interested in and responsible for the treatment of the injuries and diseases of a modern war."

THE AFTER-EFFECTS OF WOUNDS OF THE BONES AND JOINTS. By Aug. Broca, Professor of Topographical Anatomy in the Faculty of Medicine, Paris. Translated by J. Renfrew White, M.B., F.R.C.S., Temp. Captain R.A.M.C., and edited by R. C. Elmslie, M.S., F.R.C.S.; Orthopædic Surgeon to St. Bartholomew's Hospital, and Surgeon to Queen Mary's Auxiliary Hospital, Roehampton; Major R.A.M.C.(T.) With 112 illustrations in the text. Price 6/- net

This new work, like all books by the same author, is a vital and personal work, conceived with a didactic intention. At a time when all physicians are dealing, or will shortly have to deal, with the after-effects of wounds received in war, the question of sequelae presents itself, and will present itself more and more. What has become—and what will become—of all those who, in the hospitals at the front or in the rear, have hastily received initial treatment, and what is to be done to complete a treatment often inaugurated under difficult circumstances?

ARTIFICIAL LIMBS. By A. Broca, Professor in the Faculty of Medicine, Paris, and Dr. Ducroquet, Surgeon at the Rothschild Hospital. Edited and translated by R. C. Elmslie, M.S., F.R.C.S., etc.; Orthopædic Surgeon to St. Bartholomew's Hospital, and Surgeon to Queen Mary's Auxiliary Hospital, Roehampton; Major R.A.M.C.(T.). With 210 illustrations. Price 6/- net

The authors of this book have sought not to describe this or that piece of apparatus—more or less "newfangled"—but to explain the anatomical, physiological, practical and technical conditions which an artificial arm or leg *should* fulfil. It is, if we may so call it, a manual of *applied mechanics* written by physicians, who have constantly kept in mind the anatomical conditions and the professional requirements of the artificial limb.

TYPHOID FEVERS AND PARATYPHOID FEVERS (Symptomatology, Etiology, Prophylaxis). By H. Vincent, Medical Inspector of the Army, Member of the Academy of Medicine, and L. Muratet, Superintendent of the Laboratories at the Faculty of Medicine of Bordeaux. Second Edition. Translated and Edited by J. D. Rolleston, M.D. With tables and temperature charts. Price 6/- net

This volume is divided into two parts, the first dealing with the clinical features and the second with the epidemiology and prophylaxis of typhoid fever and paratyphoid fevers A and B. A full account is to be found of recent progress in the bacteriology and epidemiology of these diseases, considerable space being given to the important question of the carrier in the dissemination of infection.

The cost of postage per volume is: Inland **5d.**; *Abroad* **8d.**

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

MILITARY MEDICAL MANUALS

From THE LANCET: "The names of the editors are sufficient guarantee that the subject matter is treated with fairness and discrimination."

DYSENTERIES, CHOLERA, AND EXANTHEMATIC TYPHUS. By H. Vincent, Medical Inspector of the Army, Member of the Academy of Medicine, and L. Muratet, Superintendent of the Laboratories at the Faculty of Medicine of Bordeaux. With an Introduction by Andrew Balfour, C.B., C.M.G., M.D., Lieut.-Col. R.A.M.C. Edited by George C. Low, M.A., M.D., Temp. Capt. I.M.S. Price 6/- net

This, the second of the volumes which Professor Vincent and Dr. Muratet have written for this series, was planned, like the first, in the laboratory of Val-de-Grâce, and has profited both by the personal experience of the authors and by a mass of recorded data which the latter years of warfare have very greatly enriched. It will be all the more welcome, as hitherto there has existed no comprehensive handbook treating these great epidemic diseases from a didactic point of view.

ABNORMAL FORMS OF TETANUS. By MM. Courtois-Suffit, Physician of the Hospitals of Paris, and R. Giroux, Resident Professor. With a Preface by Professor F. Widal. Edited by Surgeon-General Sir David Bruce, K.C.B., F.R.S., LL.D., F.R.C.P., etc., and Frederick Golla, M.B. Price 6/- net

Of all the infections which threaten our wounded men, tetanus is that which, thanks to serotherapy, we are best able to prevent. But serotherapy, when it is late and insufficient, may, on the other hand, tend to create a special type of attenuated and localised tetanus; in this form the contractions are as a general rule confined to a single limb. This type, however, does not always remain strictly monoplegic; and if examples of such cases are rare this is doubtless because physicians are not as yet very well aware of their existence. We owe to MM. Courtois-Suffit and R. Giroux one of the first and most important observations of this new type; so that no one was better qualified to define its characteristics. This they have done in a remarkable manner, supporting their remarks by all the documents hitherto published, first expounding the characteristics which individualise the other atypical and partial types of tetanus, which have long been recognised.

WAR OTITIS AND WAR DEAFNESS. Diagnosis, Treatment, Medical Reports. By Dr. H. Bourgeois, Oto-rhino-laryngologist to the Paris Hospitals, and Dr. Sourdille, former interne of the Paris Hospitals. Edited by J. Dundas Grant, M.D., F.R.C.S.(Eng.); Major R.A.M.C., President, Special Aural Board (under Ministry of Pensions). With many illustrations in the text and full-page plates. Price 6/- net

This work presents the special aspects of inflammatory affections of the ear and deafness, as they occur in active military service. The instructions as to diagnosis and treatment are intended primarily for the regimental medical officer. The sections dealing with medical reports (*expertises*) on the valuation of degrees of disablement and claims to discharge, gratuity or pension, will be found of the greatest value to the officers of invaliding boards.

The cost of postage per volume is: Inland **5***d.; Abroad* **8***d.*

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

MILITARY MEDICAL MANUALS

GUY'S HOSPITAL GAZETTE: "The series is a most valuable addition to the medical literature of the war. . . . We deem it to be almost indispensable to a medical officer, and have no hesitation in unreservedly recommending it."

SYPHILIS AND THE ARMY. By G. Thibierge, Physician of the Hôpital Saint-Louis. Edited by C. F. Marshall, F.R.C.S.

Price 6/- net

It seemed, with reason, to the editors of this series that room should be found in it for a work dealing with syphilis considered with reference to the army and the present war. The frequency of this infection in the army, among the workers in munition factories, and in the midst of the civil population where this is in contact with soldiers and mobilised workers, makes it, at the present time, a true epidemic disease, and one of the most widespread of epidemic diseases. Dr. Thibierge, whose previous labours guarantee his peculiar competence in these difficult and important questions, has, in writing this manual, very notably assisted in this work. But the treatment of syphilis has, during the last six years, undergone considerable modifications; the new methods are not yet very familiar to all physicians; and certain details may no longer be present to their minds. It was therefore opportune to survey the different methods of treatment, to specify their indications, and their occasionally difficult technique, which is always important if complications are to be avoided. It was necessary before all to state precisely and to retrace, for all those who have been unable to follow the recent progress of the therapeutics of venereal diseases, the characters and the diagnostic elements of the manifestations of syphilis.

MALARIA IN MACEDONIA: Clinical and Hæmatological Features. Principles of Treatment. By P. Armand-Delille, P. Abrami, G. Paisseau and Henri Lemaire. Preface by Professor Lavern, Membre de l'Institut. Edited by Sir Ronald Ross, K.C.B., F.R.S., LL.D., D.Sc., Lieut.-Col. R.A.M.C. With illustrations and a coloured plate.

Price 6/- net

This work is based on the writers' observations on malaria in Macedonia during the present war in the French Army of the East. A special interest attaches to these observations, in that a considerable portion of their patients had never had any previous attack. The disease proved to be one of exceptional gravity, owing to the exceptionally large numbers of the Anopheles mosquitoes and the malignant nature of the parasite (Plasmodium falciparum). Fortunately an ample supply of quinine enabled the prophylactic and curative treatment to be better organised than in previous colonial campaigns, with the result that, though the incidence of malaria among the troops was high, the mortality was exceptionally low. Professor Laveran, who vouches for this book, states that it will be found to contain excellent clinical descriptions and judicious advice as to treatment. Chapters on parasitology and the laboratory diagnosis of malaria are included.

An early announcement will be made in regard to further volumes under consideration.

The cost of postage per volume is: Inland **5***d.; Abroad* **8***d.*

LONDON: UNIVERSITY OF LONDON PRESS, LTD.,
18, WARWICK SQUARE, E.C.4

147247 MS. L.

Author Leriche, R.

Title The treatment of fractures, ed. with a preface

University of Toronto Library

DO NOT REMOVE THE CARD FROM THIS POCKET

Acme Library Card Pocket
Under Pat. "Ref. Index File"
Made by LIBRARY BUREAU